

Using quality improvement approach to address missed opportunities for vaccination in Kano Metropolis, Nigeria

by

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Declaration

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This dissertation includes six published manuscripts. The conceptualization, development and writing of the manuscripts were my principal responsibility.

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Abstract

Background

Strategies to reduce missed opportunities for vaccination (MOV) can potentially increase immunization coverage in health facilities and invariably improve immunization coverage at the district and national level. Yet, there is a dearth of synthesized literature on MOV in Africa, despite being the region with the lowest immunization coverage globally.

Furthermore, the use of quality improvement (QI) in health facilities to rapidly address health system problems is growing, but evidence of its use in the immunization sub-system to reduce MOV is scarce. Moreover, it is unclear how the QI approach can be applied in a low resource, low immunization coverage setting like Kano, Nigeria. Therefore in this project, empirical evidence on the burden and dynamics of MOV in Africa was generated as well as the extent to which practitioners in healthcare facilities have used QI to address it. This was followed by the implementation and evaluation of a QI programme to reduce MOV in Nassarawa Local Government Area, Kano State, Nigeria.

Methodology

A combination of methods including systematic review, scoping review, multilevel modelling, qualitative inquiry, time series, and mixed methods were used.

Result

The first component of the first phase, a systematic review, revealed that MOV is common among children aged 0 – 23 months who made contact with health facilities in Africa, with a pooled prevalence of 27.26%. However, only 20 MOV assessments from 14 African countries were found. The reasons for MOV were multifactorial and complex because they were interrelated and interdependent. The second component of the first phase, a scoping review, revealed that evidence on the use of QI to reduce MOV and improve immunization coverage in health facilities exists. However, the QI interventions that were found were all implemented in the United States. Plan-do-study-act (PDSA) cycles were the most commonly used models. In these QI programmes, practitioners used multiple change ideas simultaneously. The change ideas were client-related, health worker-related, and cross-cutting health system-related change ideas. The second phase was the pre-implementation period of a QI programme in Kano, Nigeria. The first component of the second phase, a cross

sectional study, revealed an MOV prevalence of 36.15% among children aged 0 – 23 months who visited PHC facilities in Nassarawa Local Government Area (LGA) of Kano, Nigeria. MOV was more likely to occur among children who were accompanying a caregiver to the health facility and failure to offer vaccination on the day of clinic visit. In the second component of this phase, a qualitative study based on the lived experiences of caregivers, showed that non-screening of immunization history, refusal to offer vaccination, husband's refusal and fear of side effects were responsible for MOV. In the third phase, locally relevant change ideas were implemented in five PHC facilities in Nassarawa LGA to address the identified factors. In the first component of the third phase, frontline health workers in these facilities systematically selected and implemented change ideas in two plan-do-study-act (PDSA) cycles that were four weeks apart. Using p-charts, reduction in proportion of MOV per day was seen in two facilities at the sixth week following implementation of the PDSA cycles. Then, an evaluation of the implementation context revealed that several facilitators and barriers influenced the implementation of the QI programme.

Conclusion

This study confirmed that MOV is a common immunization problem in Kano, like other settings in Africa. A bottom-up QI approach to address MOV, that is led by health workers in facilities, is feasible in this setting. However, rapid assessment of implementation context should be built into the QI process.

Opsomming

Agtergrond

Strategieë om verlore inentingsgeleenthede (VIG) te verminder, kan moontlik inentingsdekking in gesondheidsorgfasiliteite verhoog en uiteindelik inentingsdekking op distriks- en nasionale vlakke verbeter. Nietemin is daar 'n gebrek aan gesintetiseerde literatuur oor VIG in Afrika, ofskoon dit die streek met die laagste immuniseringsdekking wêreldwyd is. Ondanks die toenemende gebruik van gehalteverbetering (GV) in gesondheidsfasiliteite om probleemoplossing in die gesondheidstelsel te bespoedig, bestaan daar min bewyse dat die immunisering-sistelsel GV gebruik om VIG te verminder. Verder is dit onduidelik hoe die GV-benadering in 'n omgewing van laehulpbron- en lae-immunisering-dekking, soos Kano in Nigerië, toegepas kan word. Hierdie projek voorsien bewyse ten opsigte van die las en dinamika van VIG in Afrika, sowel as die mate waartoe praktisyns in gesondheidsorgfasiliteite van GV gebruik maak om VIG aan te pak. 'n GV-program is vervolgens geïmplementeer en geëvalueer, wat gemik is op die vermindering van VIG in die Nassarawa Plaaslike Owerheidsgebied (POG) in die staat Kano, Nigerië.

Metodologie

'n Kombinasie van metodes, ingesluit stelselmatige oorsig, bestekbepaling, veelvlakmodellering, kwalitatiewe ondersoek, tydreëks, en gemengde metodes, is gebruik.

Resultaat

In die eerste komponent van die eerste fase, 'n stelselmatige oorsig, het dit aan die lig gekom dat VIG algemeen voorkom onder kinders van 0 tot 23 maande wat kontak gehad het met gesondheidsfasiliteite in Afrika, met 'n saamgevoegde voorkoms van 27,26%. Daar is egter slegs 20 VIG-evaluerings vir 14 Afrikalande gevind. Die redes vir VIG was multifaktoriaal en kompleks van aard omdat hul onderling verwant en interafhanklik is. In die tweede komponent van die eerste fase, 'n bestekbepaling, het dit aan die lig gekom dat daar wel bewyse bestaan vir die gebruik van GV om VIG te verminder en immunisasie-dekking in gesondheidsfasiliteite te verbeter. Die GV-intervensies wat opgespoor is, is egter almal in die Verenigde State geïmplementeer. Die algemeenste modelle wat gebruik is, was die Beplan-Doen-Bestudeer-Handel- (BDBH-)siklusse. In hierdie GV-programme het praktisyns veelvuldige veranderingsidees gelyktydig toegepas. Die veranderingsidees was kliënt-

verwant, gesondheidswerker-verwant, asook dwarssnijdende gesondheidstelsel-verwante veranderingsidees. Die tweede fase was die voorimplementeringsperiode van 'n GV-program in Kano, Nigerië. Die eerste komponent van die tweede fase, 'n deursneestudie, dui op 'n VIG-voorkoms van 36,15% onder kinders van 0 tot 23 maande, wat die primêregesondheidsorg- (PGS-)fasiliteite in die Nassarawa POG in Kano, Nigerië, besoek het. VIG kom meer algemeen voor onder kinders wat deur 'n versorger na die gesondheidsfasiliteit vergesel word en kinders wat die kliniek vanweë 'n nie-inentingsrede (soos behandeling) besoek. In die tweede komponent van hierdie fase het 'n kwalitatiewe studie, gebaseer op die ervarings van versorgers, getoon dat die nie-sifting van die inentingsgeskiedenis, die weiering om inenting aan te bied, die man se weiering, en vrees vir nuwe-effekte, vir VIG verantwoordelik was. In die derde fase is plaaslik-relevante veranderingsidees in vyf PGS-fasiliteite in die Nassarawa POG geïmplementeer om die geïdentifiseerde faktore mee aan te pak. In die eerste komponent van die derde fase het gesondheidswerkers in die voorste linie in hierdie fasiliteite stelselmatig veranderingsidees uitgekies en geïmplementeer in twee BDBH-siklusse wat vier weke uit mekaar geskeduleer is. Deur die gebruik van p-grafieke is die vermindering van die proporsie VIG's per dag in twee fasiliteite in die sesde week ná die implementering van die BDBH-siklusse waargeneem. Daarna het 'n evaluering van die implementeringskonteks uitgewys dat verskeie fasiliteerders en hindernisse die implementering van die GV-program beïnvloed.

Gevolgtrekking

Hierdie studie bevestig dat VIG 'n algemene immuniseringsprobleem in Kano is, soos in ander omgewings in Afrika. 'n Onder-na-bo-benadering tot GV vir die aanpak van VIG, gelei deur gesondheidswerkers in fasiliteite, is haalbaar in hierdie omgewing. Snelle evaluering van die implementeringskonteks moet egter by die GV-proses ingebou word.

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List of publications

Study	Status	Journal
Prevalence and dynamics of missed opportunities for vaccination among children in Africa: Applying systems thinking in a systematic review and meta-analysis of observational studies. DOI: https://doi.org/10.1080/14760584.2019.1588728	Published	Expert Review of Vaccines
Application of quality improvement approaches in healthcare settings to reduce missed opportunities for childhood vaccination: a scoping review. DOI: https://doi.org/10.1080/21645515.2019.1600988	Published	Human Vaccines and Immunotherapeutics
A multilevel analysis of the determinants of missed opportunities for vaccination among children attending primary healthcare facilities in Kano, Nigeria: findings from the pre-implementation phase of a collaborative quality improvement programme. DOI: https://doi.org/10.1371/journal.pone.0218572	Published	PLOS ONE
Using the theoretical domains framework to explore reasons for missed opportunities for vaccination among children in Kano, Nigeria: a qualitative study in the pre-implementation phase of a collaborative quality improvement project. DOI: https://doi.org/10.1080/14760584.2019.1643720	Published	Expert Review of Vaccines
Implementation and evaluation of a collaborative quality improvement project to improve immunization rate and reduce missed opportunities for vaccination in primary health care facilities: a time series study in Kano, Nigeria. DOI: https://doi.org/10.1080/14760584.2019.1647782	Published	Expert Review of Vaccines
Using the consolidated framework for implementation research (CFIR) to assess the implementation context of a quality improvement programme to reduce missed opportunities for vaccination in Kano, Nigeria: a mixed methods study. DOI: https://doi.org/10.1080/21645515.2019.1654798	Published	Human Vaccines and Immunotherapeutics

Conference attended

Name of conference	Abstract title	Type
International Epidemiological Association (IEA) 5 th African Regional Conference, Maputo, Mozambique. 14 th – 17 th April 2019.	Using a systems dynamic approach to explore the factors that are responsible for missed opportunities for vaccination in Africa: identifying leverage points for quality improvement	Poster presentation
5 th African Conference on Emerging Infectious Diseases and Biosecurity, Abuja, Nigeria. 7 th – 9 th August 2019.	Vaccination in the era of emerging infectious diseases: are we missing opportunities?	Oral presentation

List of abbreviations

Abbreviation	Full meaning
BCG	Bacillus Calmette-Guerin
BCW	Behavior Change Wheel
CFIR	Consolidated Framework for Implementation Research
CI	Confidence Interval
CrI	Credible Interval
DHS	Demographic and Health Survey
DIC	Deviance Information Criterion
DTP	Diphtheria-Tetanus-Pertussis containing vaccine
EPI	Expanded Programme on Immunization
GAVI	Global Alliance for Vaccines and Immunization
GVAP	Global Vaccine Action Plan
HBV	Hepatitis B Vaccine
Hib	Hemophilus influenza type b
ICC	Intra Cluster Coefficient
IPV	Inactivated Polio Vaccine
ISF	Interactive Systems Framework for Dissemination and Implementation
LGA	Local Government Area
MCV	Measles Containing Vaccine
MOR	Mean Odds Ration
MOV	Missed Opportunities for Vaccination
NPHCDA	National Primary Health Care Development Agency
OPV	Oral Polio Vaccine
OR	Odds Ratio
PCV	Pneumococcal Conjugate Vaccine
PDSA	Plan Do Study Act
PHC	Primary Health Care
PRISMA	Preferred Reporting Item for Systematic Review and Meta-Analysis
PROSPERO	International Prospective Register for Systematic Reviews
QI	Quality Improvement
TDR	Theoretical Domains Framework
UNICEF	United Nation's Children Fund
WHO	World Health Organization

Chapter 1: General introduction

1.0 About this chapter

In this chapter, we provide a general overview of the project by discussing vaccine-preventable diseases, child mortality, childhood immunization coverage in Nigeria, missed opportunities for vaccination (MOV) and quality improvement (QI). In addition, we provide the justification and scope of the PhD project including the research questions and objectives.

1.1 Background

1.1.1 Vaccine-preventable diseases and child mortality

Under-five mortality has remained disproportionately high in sub-Saharan Africa (SSA) (1). According to the 2018 report by the United Nations Inter-agency Group for Child Mortality Estimation, under-five mortality rate in SSA is 76 per 1000 live births, which is the highest in the world (1). However, between-country disparities exist (2). Spatial analysis revealed that Nigeria and the Democratic Republic of Congo (DRC) have higher mortality rates with concomitant slow progress towards reduction, compared to other countries (2). Although several causes of under-five death have been identified, infectious diseases still make substantial contributions (3).

Among the leading infectious causes of child mortality are pneumonia, meningitis, sepsis, diarrhea and measles (3). Pneumonia accounts for about 15% of all under-five mortality in SSA (3). Nigeria, DRC and Ethiopia are among the countries with the highest number of child deaths resulting from pneumonia (4). The most commonly implicated pathogens are *Streptococcus pneumoniae* and *Hemophilus influenzae* (4). *S. pneumoniae* is a gram positive, non-motile, non-spore forming, facultative anaerobic bacterium (5, 6). While *H. influenzae* is a gram negative, coccobacillary, pleomorphic, facultative anaerobic bacterium (7). The encapsulated strains of *H. influenzae* are classified into six types based on their capsular antigen, namely; *a*, *b*, *c*, *d*, *e*, and *f* (7). The unencapsulated strains are non typable (NTHi) (8). In addition to pneumonia, these organisms also cause sepsis and meningitis (9).

Rotavirus infection is an important cause of diarrhea in children as it resulted in an estimated 250,000 child death in SSA in 2000 (10-13). Out of the estimated 310,967 diarrhea deaths that occurred in SSA in 2013, 121,009 which represents 38.9%, was caused by rotavirus (13). Seven out of the ten countries that account for two-third of all deaths due to rotavirus infection globally are in SSA (13). Nigeria alone contributed 14% of all rotavirus mortality among under-five children in 2013 (13).

Measles is a contagious viral infection that is an important cause of morbidity and mortality among children in SSA (14). In 2014, it was estimated to have caused 73,914 deaths in SSA, which is about 63% of child deaths caused by the virus globally (15, 16).

Other important causes of child morbidity and mortality include pertussis, tetanus, tuberculosis, and hepatitis B virus infection among others (17).

1.1.2 Childhood immunization

Immunization can protect children from these common infectious diseases and for this reason, it is regarded as one of the most important health interventions for promoting child survival and safeguarding public health (18, 19). It is considered to be highly cost-effective because it yields significant cost-savings for governments and families in illness averted (20). According to the global burden of disease (GBD), global under-five mortality was reduced from 16.4 million in 1970 to 5.0 million in 2016, and this decline has been attributed, in part, to population-wide immunization programmes (21, 22). The World Health Organization estimates that immunization prevents about 3 million child deaths every year (23).

The immense public health value of immunization prompted the World Health Organization to launch the Expanded Programme on Immunization (EPI) in 1974, as the first ever global health effort to promote and ensure universal access to vaccines for all children (24). The EPI technical strategic framework stresses equitable access to vaccines, achieving vaccine-preventable disease elimination and eradication, justifiable new vaccine introduction, disease surveillance and strengthening partnerships among others (25).

One of the core indicators for measuring the performance of EPI at national and global level is immunization coverage (26). According to the WHO, “it is defined as the proportion of a

population that has been vaccinated in a given time period” (26). It’s usually measured for each vaccine (e.g. measles containing vaccine) and each dose of multi-dose vaccine (e.g. first second and third dose of diphtheria-tetanus-pertussis containing vaccine (DTP1, DTP3, and DTP3)) received by national immunization programmes (26). Based on the Global Vaccine Action Plan (GVAP) target which was endorsed by 194 WHO member countries, DTP3 coverage should reach at least 90% at national level and 80% at district level by 2020 (27). Going by current trajectories, immunization programs are still not as efficient as expected because an estimated 19 million infants do not have access to vaccines, majority of which are in sub-Saharan Africa (28, 29). In fact, DTP3 coverage in the Africa region has stalled at about 70% - 72% since 2015 (30). The countries with the lowest level in the African region are Equatorial Guinea, South Sudan, Chad and Nigeria (30).

1.1.3 Routine immunization coverage in Nigeria

Nigeria has the highest number of unimmunized and partially immunized children globally with DTP3 coverage of 42% (30). The country, which is the most populous in sub-Saharan Africa, adopted EPI in 1979 to provide routine immunization services to all children (31). To ensure widespread adoption of immunization among other basic health services, national and state primary health care development agencies were created (32). Functionally, the National Primary Health Care Development Agency (NPHCDA) formulates policies, procedures and guidelines to support routine immunization service implementation in primary, secondary and tertiary health facilities across the country (31). On account of the high rates of child mortality in the country, new vaccines such as pentavalent vaccine (diphtheria, tetanus, pertussis, *Hemophilus influenzae type b*, and hepatitis b containing vaccine) pneumococcal conjugate vaccine, rotavirus vaccine and inactivate polio vaccine were introduced by the Federal Ministry of Health in addition to other traditional EPI vaccines between 2012 and 2015 (33-36).

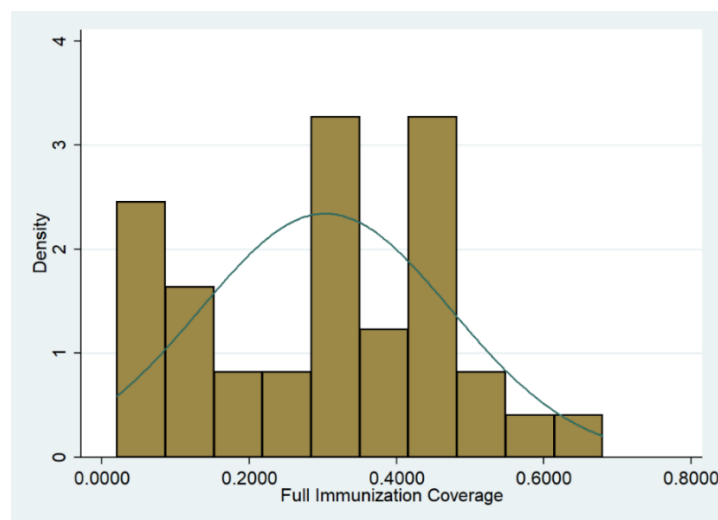
The country’s current routine immunization schedule is shown on Table 1.1(37):

Table 1.1: National routine immunization schedule in Nigeria

Age	Vaccine offered
At Birth	BCG, OPV 0, HBV – Birth dose within 24 hours of birth.
At 6 Weeks	PENTA 1, OPV 1, Rotavirus vaccine 1, PCV 1
At 10 Weeks	OPV 2, PENTA 2, PCV 2, Rotavirus vaccine 2
At 14 Weeks	OPV 3, PENTA 3, PCV 3, IPV
At 9 Months	Measles Vaccine, Yellow Fever Vaccine, Vitamin A

(BCG = Bacille Calmette Guerin, OPV = Oral Polio Vaccine, HBV = Hepatitis B Vaccine, PENTA = Pentavalent Vaccine (diphtheria, tetanus, pertussis, *Hemophilus influenzae tybe b*, and hepatitis b containing vaccine), PCV = Pneumococcal Conjugate Vaccine, IPV = Inactivated Polio Vaccine)

However, the performance of the immunization programme in Nigeria has been suboptimal as the country has one of the lowest DTP3 coverage levels in the world (31, 38). According to the National Immunization Coverage Survey (NICS) conducted in 2017, only 23% of children aged 12 – 23 months are fully immunized (39). Within Nigeria, wide disparity in immunization coverage exist across states (39). For example, Jigawa State has coverage of 2% while coverage level in Lagos is 68% (39). This variation in immunization coverage across states is illustrated in the histogram shown in Figure 1.1. The histogram was constructed using coverage level per state. Although the Shapiro-Wilk test and Shapiro-Francia test revealed a p-value of 0.14 and 0.27 (suggesting normal distribution) respectively, the histogram shows a mixture of distributions.

**Figure 1.1: Histogram of full immunization coverage across states in Nigeria**

For specific vaccines, coverage with Bacillus Calmette-Guerin (BCG), birth dose hepatitis B vaccine, birth, first, second and third dose oral polio vaccine (OPV0, OPV1, OPV2 and OPV3) in Nigeria were 53%, 30%, 47%, 50%, 42% and 33% respectively (39). Also, coverage with first, second and third dose of diphtheria-tetanus-pertussis *Hemophilus influenza type b* and hepatitis b containing vaccine (pentavalent vaccine), measles containing vaccine and yellow fever vaccine were 49%, 40%, 33%, 42% and 39% respectively according to the survey (39). These are below the targets endorsed by WHO member nations in the Global Vaccine Action Plan (GVAP) (40).

Majority of the unimmunized and partially immunized children are in the Northern part of the country (39). This was determined by dividing immunization coverage across all states in the country into quartiles. The states in the lowest quartile (25th) of full immunization coverage in Nigeria are shown in Figure 1.2 and they comprise of Jigawa, Sokoto, Kebbi, Zamfara, Katsina, Yobe, Kano, Taraba, Niger and Bauchi (39).

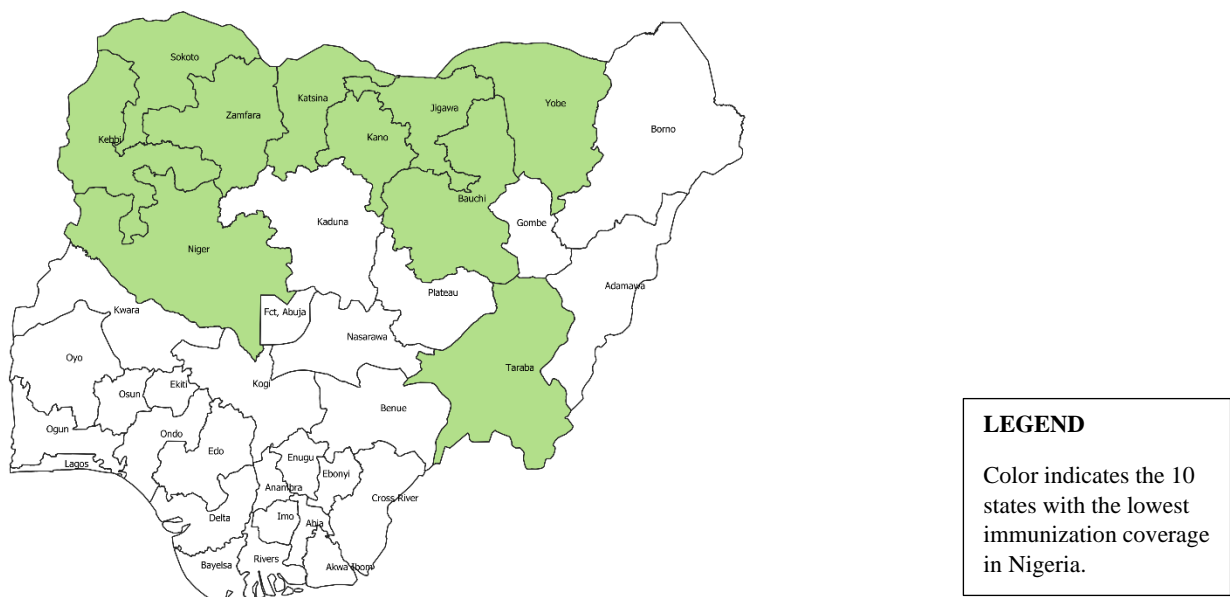
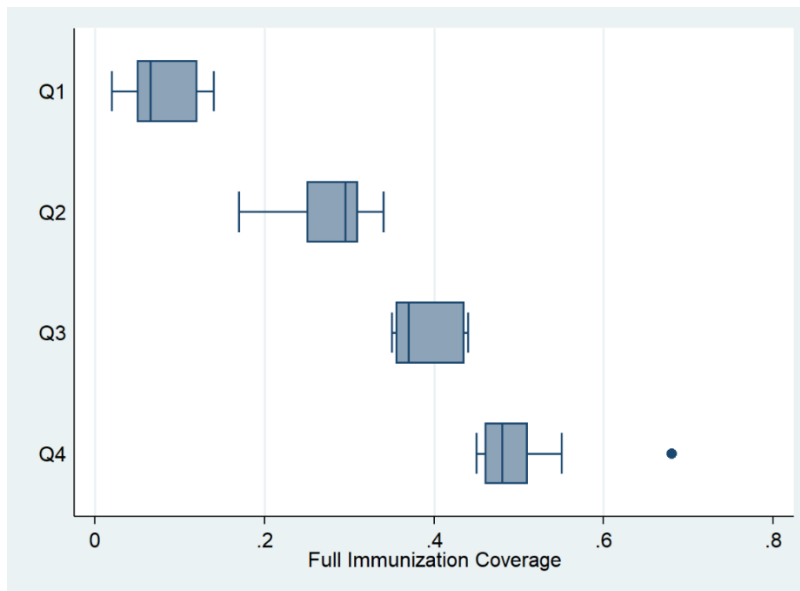


Figure 1.2: Map of Nigeria showing 10 states with lowest full immunization coverage

Figure 1.3 is a boxplot of immunization coverage for each of the four quartiles. Quartile 1 (Q1), which represents the 10 states with the lowest immunization coverage has a minimum coverage level of 2% and maximum coverage level of 14%, with a median of 6% as illustrated in Figure 1.3 (39).



Q = Quartile

Figure 1.3: Boxplot of full immunization coverage across states in Nigeria

In Kano State, which is the most populous state in the North West geopolitical zone, full immunization coverage is 10% (39). Additionally, coverage with OPV3, Penta 3, yellow fever vaccine and measles containing vaccine in the state are 14%, 16%, 22% and 24% respectively (39).

Several socio-ecological factors have been identified as predictors of low routine immunization coverage (41). They include poor knowledge about vaccines among parents, inadequate access to immunization-related behavior change and organization of immunization system among several others (41). Interestingly, a significant urban inequality (i.e. slum/non-slum disparities) in immunization coverage has been observed (42-44). A study conducted in 2010 reported that less than 10% of Nigerian children in slum areas were fully immunized (44). Recent studies have

confirmed this inequality, and researchers have associated it with the rapid rate of urban population growth due to rural-urban migration (42, 45). It was found that children of urban migrants have a significantly lower chance of getting immunized in the country compared to other children in the community (44). Although immunization inequity is narrowing in developing countries like Bangladesh, the disparity is widening in Nigeria (45).

1.1.4 Missed opportunities for vaccination

Missed opportunities for vaccination (MOV) in health services setting have also been identified as an important contributor to low routine immunization coverage (46). MOV is defined as “*any contact with health services by a child (or adult) who is eligible for vaccination (unvaccinated, partially vaccinated, or not up-to-date, and free of contraindications to vaccination), which does not result in the individual receiving all the vaccine doses for which he or she is eligible*” (29). It can occur in two settings; during a visit to the health facility for immunization and other preventive care services, or during a visit to the health facility for curative services (29).

In 1993, a review of MOV in high and low income countries found a median prevalence of 32% among children and women of child bearing age (47). A more recent review which included children aged 0 – 18 years found a pooled prevalence of 32.2% (48). In this review, MOV in tertiary setting in Nigeria for specific antigens were also reported (BCG = 5%, DPT = 48%, Measles = 70%, and OPV = 46.7%) (48). Results from primary studies have estimated the prevalence of missed opportunities for vaccination in Nigeria’s tertiary hospitals to vary from 17% to 39.1% (49, 50). Some of the supply-side causes include; inability to screen children for eligibility, vaccine shortages at health facilities, poorly motivated health workers, distance from health facility, clinic schedules, lack of resources and wrong contraindication (41). Demand-side causes are education level and religious beliefs of parents, as well as parental knowledge among others (41).

MOV is a quality of care issue and recently, the World Health Organization (WHO) reinvigorated its commitments to addressing it as a strategy to further improve immunization coverage; which is a key population health indicator (29). In order to harmonize health system response to MOV, an MOV strategy was developed, which has also being endorsed by WHO’s strategic advisory group of experts (SAGE) on immunization in April 2016 (51). This strategy

promotes the systematic analysis of MOV burden and implementation of context specific innovations to improve immunization rates in existing immunization sites (51, 52). The MOV strategy focuses on three areas: burden of missed opportunities, reasons for opportunities being missed, and what can be adjusted or done differently (52). In the current planning guide, assessment is recommended in children aged 0 – 23 months and tailored innovations are advocated (46).

The success of the MOV strategy depends on the functionality of existing health systems, and health facilities providing immunization services are not usually as effective in urban slum areas (53). This is as a result of lack of basic infrastructures like water, and electricity (to maintain cold chain), which prevents proper functioning (53). In addition, the number of healthcare personnel, and the capacity of health facilities in slum areas are usually inadequate, with characteristic long waiting times, all of which can cause MOV (53, 54).

1.1.5 Quality improvement

Quality improvement (QI), which originated from industrial manufacturing, has become a popular approach for addressing patient, provider, and systems related problems in health care settings to attain improved patient and population health outcomes, as well as reduced cost (55). It relies on the combined and unceasing efforts of all stakeholders to make changes that will result in the desired outcome (55). The rationale is that quality practices in healthcare settings improve performance (56). As such, a quality improvement process involves continuous outcome and process measurement, a tailored change intervention (also called change idea), and thoughtfully reviewing the on change implemented vis-à-vis desired outcome, all of which are done in an iterative manner (56).

Several quality improvement methodologies exist (57). Six sigma is used for correcting defects within systems (58). There are two known six sigma frameworks and they include; Define Measure Analysis Improve and Control (DMAIC) and Define Measure Analyze Design and Verify (DMADV) (58). Lean method is useful for reducing waste within systems (58). A third method known as Model for Improvement (MFI) has been developed by the Institute for Healthcare Improvement (59). In this model, three fundamental questions are asked: “*what are we trying to accomplish, how will we know that a change is an improvement and what changes*

can we make that will result in improvement” (60). These three questions are then combined with the Plan-Do-Study-Act (PDSA) cycle (60).

Quality improvement (QI) has been used in the field of child health to reduce infection rates in neonates, and improve asthma care among others (61, 62). It has also been used in low and middle income countries to reduce maternal mortality, child mortality, and improve adherence to clinical practice guidelines (62). Therefore, within facilities, it can potentially be used to address the factors responsible for MOV through rapid cycles, since they are mostly related to efficiency and timeliness. However, other social determinants of low immunization coverage that are prevalent in urban areas with slum settings will require a more comprehensive government effort. This will require the involvement of other sectors outside the healthcare system.

1.2 Problem statement

There is still a dearth of synthesized evidence on the magnitude of MOV in Africa even though the region has the lowest immunization coverage globally. Despite growing interest in the use of QI in healthcare settings, evidence on the extent to which it has been used across different contexts to address MOV is scarce. In Kano, routine immunization services are mainly provided by primary health care (PHC) facilities as this level of healthcare is closest to where people live and work. However, the prevalence of MOV among children in this setting is poorly understood. In addition, there is paucity of research evidence on how QI can be used to address MOV within this context.

1.3 Justification

In 2012, world leaders during the World Health Assembly endorsed the Global Vaccine Action Plan (GVAP) to ensure that the benefit of immunization is extended to all children that needs it (63). Having realized that African countries are lagging behind on the targets that were set in this global plan, the continent’s leaders renewed their commitment to immunization in a declaration in Addis Ababa (Addis Ababa 2016). One of the potential strategies that can be used to improve access to vaccination for children is to reduce MOV among children who make contact with health facilities. Therefore, there is a need to understand the burden of MOV in Africa as well as the factors that are responsible for it. In Nigeria, Kano State has one of the lowest immunization

coverage so addressing MOV in this setting is a pressing public health need. Hence, research evidence on how approaches like QI can be used as part of the MOV strategy to address it needs to be explored.

The project started with the synthesis of existing literature on MOV in Africa. This contributed new knowledge on the overall burden of MOV among children on the continent and the factors that are responsible for it. Such information is important for stakeholders as it can be used to support health systems policies targeted at childhood immunization. It also provided important insights on settings with research gaps. Existing literature on the extent of use of QI to address MOV was also synthesized. This enabled better understanding of the type of change ideas that have been used in other settings and the stakeholders that were targeted.

A QI programme was then initiated in Kano State, specifically, in Nassarawa Local Government Area (LGA). This LGA is one of the metropolitan LGAs in the state. A map of Kano highlighting the LGA is shown in Figure 1.4.

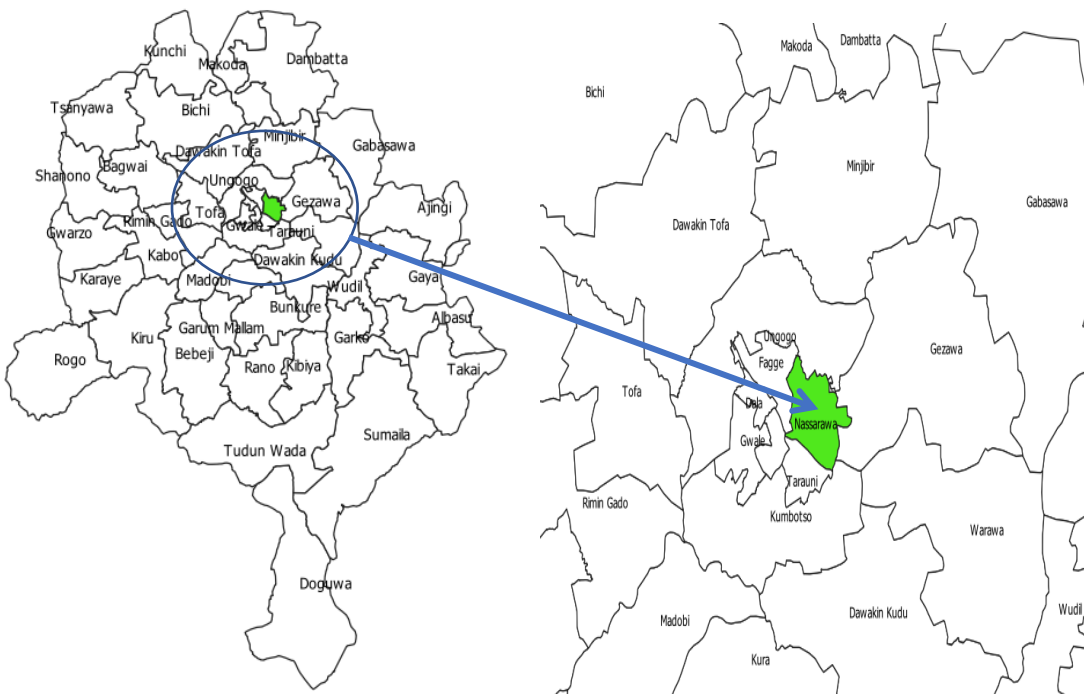


Figure 1.4: Map of Kano showing Nassarawa Local Government Area

In the pre-implementation phase of the QI programme, context-specific factors that are responsible for MOV were explored. This informed a better understanding of the burden of

MOV in the context. Additionally, it aided the selection and tailoring of change ideas (QI interventions) that were used in the QI programme.

The “real-world” setting of this research meant that the results from the study could be used to directly inform policies aimed at improving routine immunization coverage in this area. It led to the identification of change ideas that can be applied in other PHC facilities within Kano, Nigeria.

1.4 Research questions and specific objectives

1.4.1 Overarching research question

Are missed opportunities for vaccination among children aged 0 – 23 months a significant health systems problem in African countries, and how can a quality improvement approach be used to reduce them in Kano, Nigeria?

1.4.2 Sub research questions (illustrated in Figure 1.5)

- a) What is the overall prevalence and dynamics of missed opportunities for vaccination among children aged 0 – 23 months attending healthcare facilities in Africa?
- b) What is the nature and extent of use of quality improvement approaches in health facilities to reduce missed opportunities for vaccination within the context of routine childhood immunization globally?
- c) What are the predictors of missed opportunities for vaccination among children aged 0 – 23 months attending primary health care facilities in Nassarawa Local Government Area of Kano State, Nigeria?
- d) Based on the experiences of caregivers, what factors are responsible for missed opportunities for vaccination among children less than two years who attend primary health care facilities in Nassarawa Local Government Area of Kano State, Nigeria?
- e) Can quality improvement reduce missed opportunities for vaccination among children aged 0 – 23 months attending primary health care facilities in Nassarawa Local Government Area of Kano State, Nigeria?

- f) What contextual factors affect the implementation of a quality improvement programme to reduce missed opportunities for vaccination among children aged 0 – 23 months attending primary health care facilities in Nassarawa Local Government Area of Kano State, Nigeria?

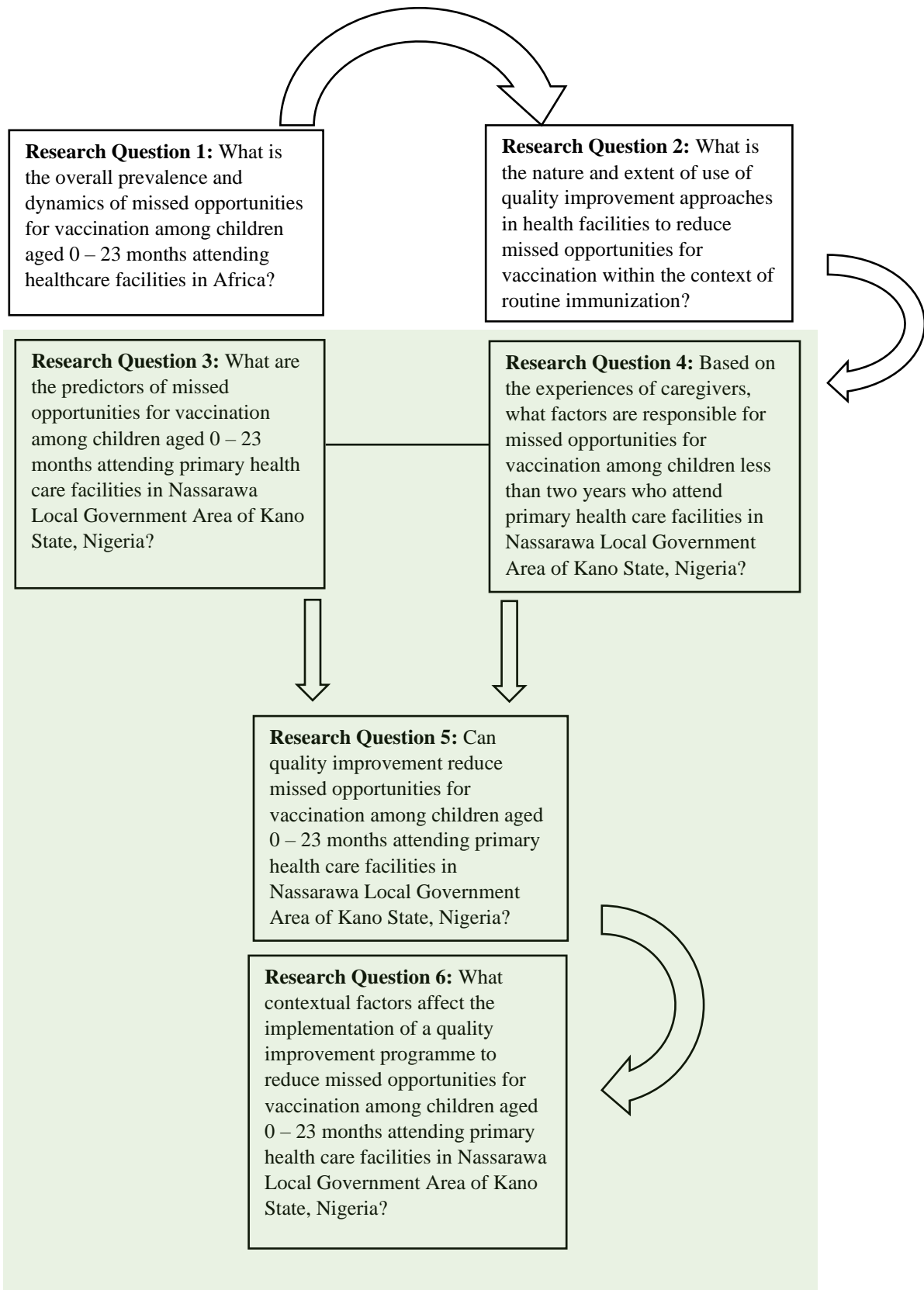


Figure 1.5: Flow of the research questions in this PhD project

1.4.2 Specific objectives

1. To estimate the prevalence of missed opportunities for vaccination among children aged 0 – 23 months attending healthcare facilities in Africa and to explore the dynamics of factors responsible for it.
2. To explore the extent to which quality improvement has been used in healthcare settings globally to address MOV.
3. To determine factors responsible for missed opportunities for vaccination among children aged 0 – 23 months attending primary healthcare facilities in Nassarawa Local Government Area, Kano State.
4. To explore reasons for missed opportunities for vaccination from the perspectives of caregivers of children aged 0 – 23 months attending primary healthcare facilities in Nassarawa local government area, Kano State.
5. To implement a quality improvement programme for addressing missed opportunities for vaccination among children aged 0 – 23 months attending primary healthcare facilities in Nassarawa, Kano State.
6. To explore the facilitators and barriers to implementing a collaborative quality improvement programme to address missed opportunities for vaccination in primary healthcare facilities in Nassarawa, Kano State.

1.5 Conceptual framework and theory of change

This dissertation postulated a general conceptual framework (as shown in Figure 1.6) that systematically described the linkage between individual components of the project. The framework served as a blueprint of how the various components of the PhD interrelate.

Multiple levels of factors involving different stakeholders can result in MOV among children aged 0 – 23 months. The framework posits that generating broad insights into the magnitude of MOV on a continental level including factors that are responsible for it is an essential first step. Furthermore, the framework supports the argument that to reduce MOV within a specific setting, a nuanced understanding of factors within that context is also critical. This is because the dynamic nature of health system contextual parameters can cause the determinants of MOV to also vary from one place to another. To do this, robust assessment of individual (caregiver and child)- and health facility- related factors in addition to an in-depth exploration of the lived experiences of caregivers attending PHC facilities in Nassarawa LGA was linked to the PDSA cycles. The arrows indicate that this has to occur in iterations. Since the change ideas are implemented by health workers in PHC facilities, the implementation context needs to be taken into consideration as well.

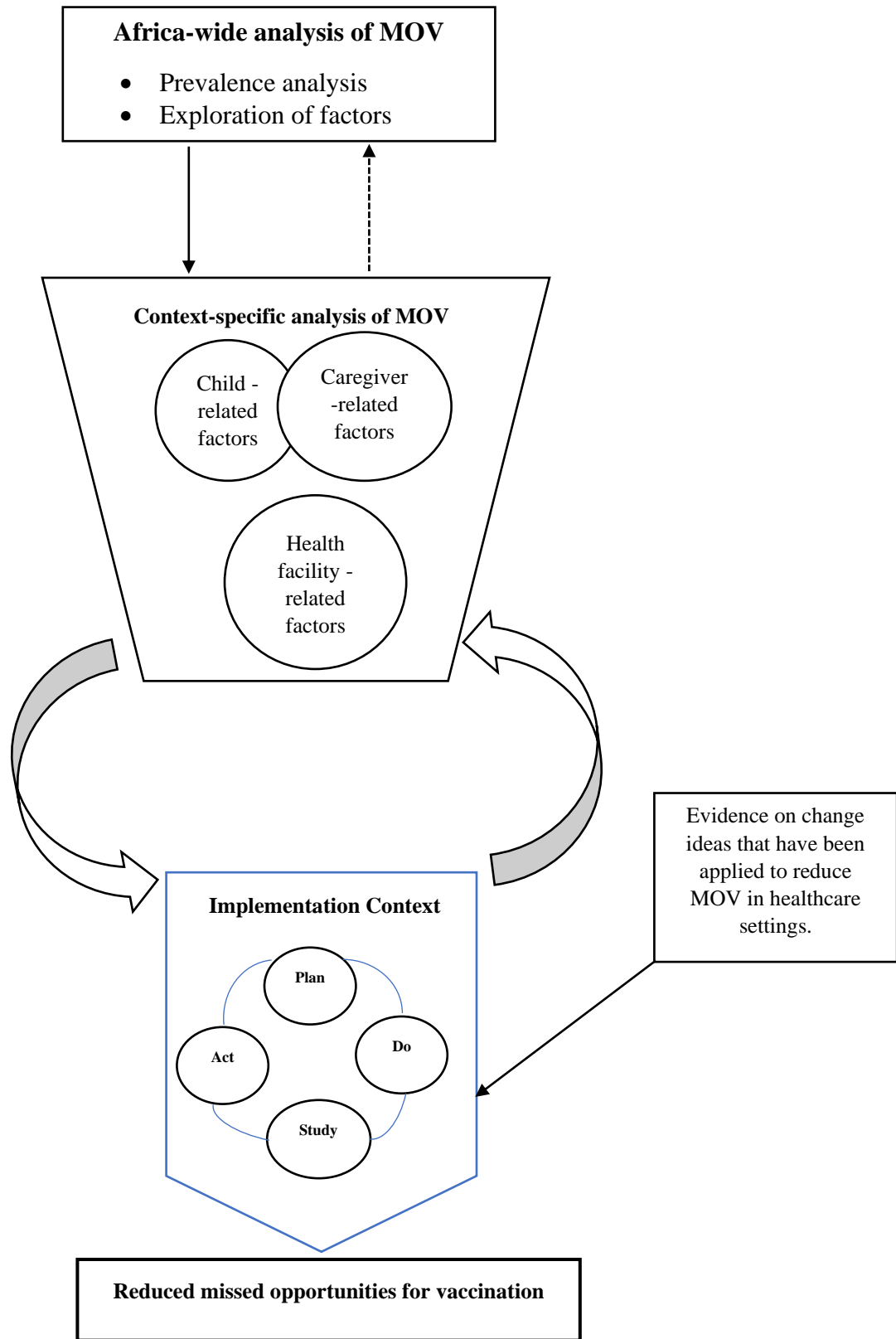


Figure 1.6: Conceptual framework on using quality improvement approaches to address missed opportunities for vaccination in Kano metropolis, Nigeria

In this project, an adaptation of the PRECEDE-PROCEED model was used to guide the application of QI approaches in PHC facilities in Nassarawa LGA, Kano, Nigeria (64). PRECEDE stands for Predisposing, Reinforcing, and Enabling Constructs in Educational/Environmental Diagnosis and Evaluation (64). While PROCEED means Policy, Regulatory, and Organizational Constructs in Educational and Environmental Development (64). In simple terms, PRECEDE are the necessary activities that should be conducted before implementing a programme, while PROCEED are the activities that should be conducted after the programme has been implemented (64). Using this model explainshow we used QI to achieve the planned change (reduction in MOV) in this study in a systematic manner (64).

This theoretical framework has three clearly demarcated stages which include planning, implementation and evaluation (64). The planning stage comprises of four sequential phases namely; social assessment, epidemiological, behavioral and environmental assessment, educational and ecological assessment, and administrative/policy assessment and intervention alignment (64). Implementation only comprises the implementation phase, while evaluation comprises process impact and outcome evaluation (64). This model was born out of the need for researchers involved in designing new programmes to focus more on addressing demonstrated needs and aspirations of target population (64). One of its key advantages is that it promotes an ecological approach to implementation rather than individual and this is well suited for this QI project that targets PHC facilities (64).

Figure 1.7 is the adapted PRECEDE-PROCEED framework that was used for this study. Administrative assessment and intervention alignment was regarded as the first phase to emphasize the critical need for early engagement of local immunization stakeholders in the planning stage. The next phase was MOV assessment to explore epidemiological, behavioral and environmental factors that are responsible for MOV among children aged 0 – 23 months that are attending PHC facilities in the LGA. Then educational assessment was performed to develop deeper insights on the facilitators and barriers of MOV. Social assessment was not included in this framework as the value of immunization in promoting child survival is already well established. The context-specific data that was collected in the planning phase then informed the selection and implementation of change ideas that are “fit” for PHC facilities in the LGA in phase four. To foster the attainment of implementation success, the implementation context

within which the change ideas were being implemented was also evaluated in the same phase. The information from evaluating the implementation context was then used to modify the change ideas and implementation strategies. The framework asserted that outcome evaluation should be conducted before impact evaluation. So the sequence of the evaluation phase was process, outcome and then impact. However, the impact of addressing MOV is reflected in the immunization coverage and assessing coverage is beyond the scope of this work.

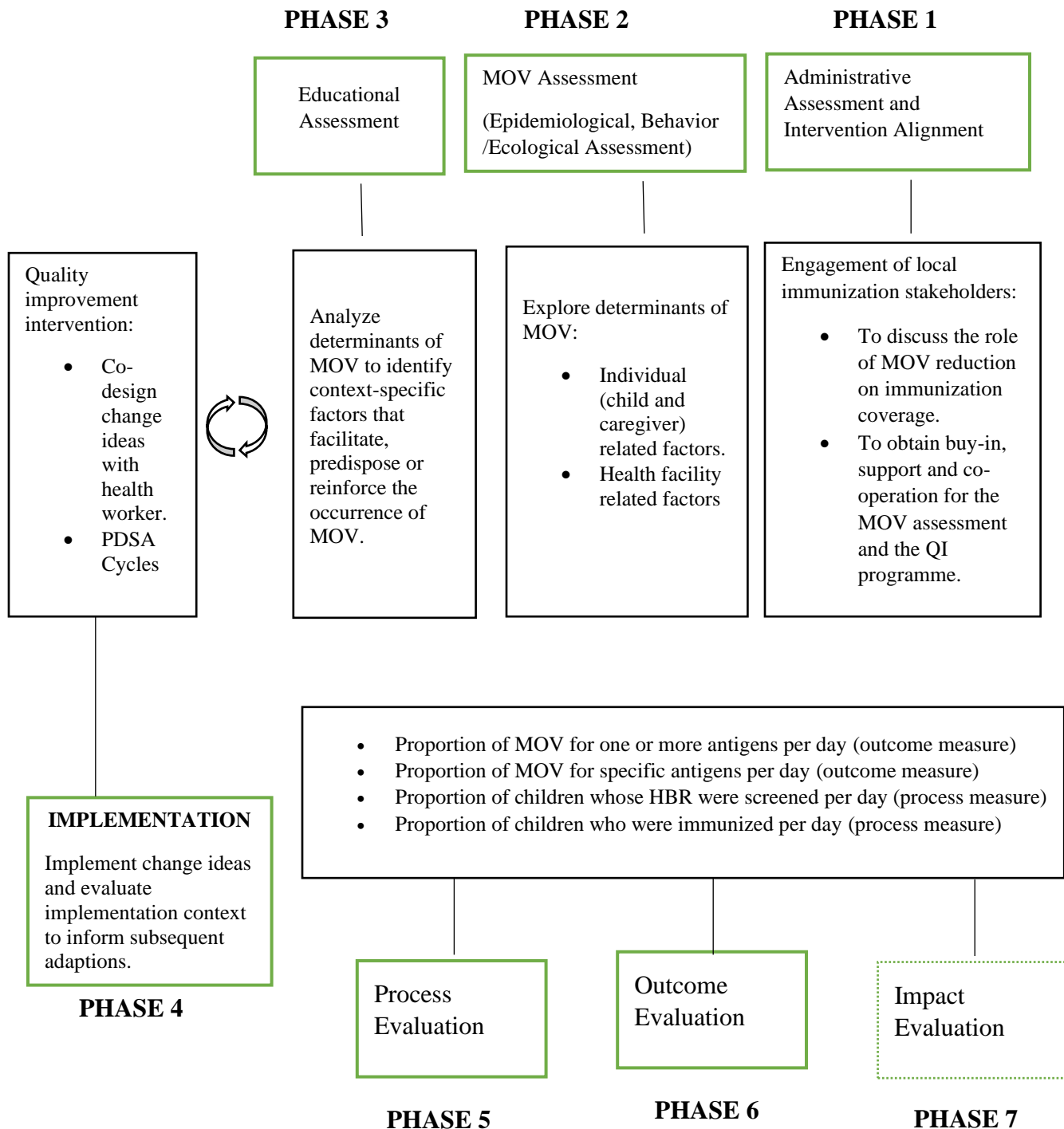


Figure 1.7: Theoretical framework on using quality improvement approaches to address missed opportunities for vaccination in Kano metropolis, Nigeria

1.6 Dissertation outline

This is a publication format dissertation as approved by the Faculty of Medicine and Health Sciences, Stellenbosch University, South Africa. Therefore, the accepted author version of the articles are included without modification. Chapter two to seven are research papers as such they are structured like manuscripts. It was necessary to provide adequate background and context in each of these chapters as they are standalone research papers, so repetitions exist especially in the introductory sections. Chapter one provides a general introduction while chapter eight provides conclusion. An outline of the chapters is described below on **Table 1.2**.

Table 1.2: Outline of chapters in the dissertation

CHAPTER	DESCRIPTION
Chapter 1	Provides a brief description of immunization coverage, MOV and QI.
Chapter 2	Provides an overview of MOV in Africa.
Chapter 3	Describes how QI has been used to address MOV
Chapter 4	Reports the quantitative analysis of the burden of MOV and its predictors among children attending primary health care facilities in Nassarawa LGA, Kano
Chapter 5	Reports the qualitative analysis of the factors that are responsible for MOV from the perspective of caregiver of children aged 0 – 23 months attending primary health care facilities in Nassarawa LGA, Kano
Chapter 6	Describes the implementation and evaluation of a QI project to reduce MOV in Nassarawa LGA, Kano
Chapter 7	Describes the evaluation of the implementation context of the QI project
Chapter 8	Provides a conclusion

This project was conducted in three phases. In the first phase, existing evidence on the burden of MOV and extent of use of QI to address it were synthesized. The second phase was the pre-implementation phase of the QI programme in Nassarawa, Kano. In this phase the burden of MOV as well as the factors that are responsible for it were contextualized. In the third phase, change ideas were implemented and evaluated and the implementation context was explored. A schematic representation of these phases are shown in **Figure 1.8**.

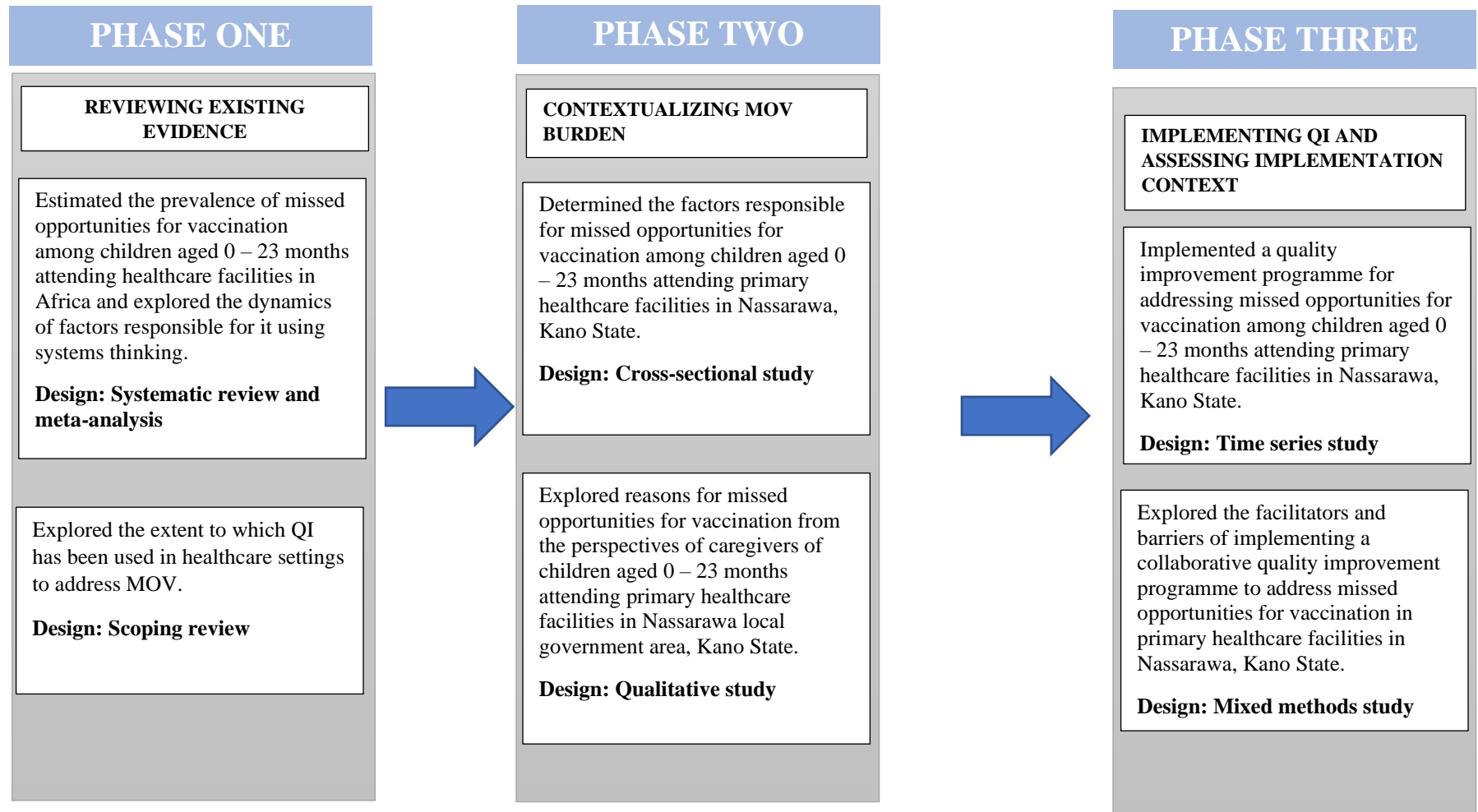


Figure 1.8: Schematic representation of the phases of this PhD project

1.7 References

1. UN Inter-agency Group for Child Mortality Estimation. Level and trend in child mortality. New York, USA: United Nations Children's Fund; 2018.
2. Burke M, Heft-Neal S, Bendavid E. Sources of variation in under-5 mortality across sub-Saharan Africa: a spatial analysis. *Lancet Glob Health*. 2016;4(12):e936-e45.
3. Liu L, Oza S, Hogan D, Chu Y, Perin J, Zhu J, et al. Global, regional, and national causes of under-5 mortality in 2000–15: an updated systematic analysis with implications for the Sustainable Development Goals. *The Lancet*. 2016;388(10063):3027-35.
4. Rudan I, Boschi-Pinto C, Biloglav Z, Mulholland K, Campbell H. Epidemiology and etiology of childhood pneumonia. *Bull WHO*. 2008;86(5):408-16.
5. Bogaert D, De Groot R, Hermans PW. *Streptococcus pneumoniae* colonisation: the key to pneumococcal disease. *Lancet Infect Dis*. 2004;4(3):144-54.
6. Tettelin H, Nelson KE, Paulsen IT, Eisen JA, Read TD, Peterson S, et al. Complete genome sequence of a virulent isolate of *Streptococcus pneumoniae*. *Science*. 2001;293(5529):498-506.
7. Whittaker R, Economopoulou A, Dias JG, Bancroft E, Ramliden M, Celentano LP. Epidemiology of invasive *Haemophilus influenzae* disease, Europe, 2007–2014. *Emerging infectious diseases*. 2017;23(3):396.
8. Langereis JD, de Jonge MI. Invasive Disease Caused by Nontypeable *Haemophilus influenzae*. *Emerg Infect Dis*. 2015;21(10):1711-8.
9. Sáez-Llorens X, McCracken Jr GH. Bacterial meningitis in children. *The lancet*. 2003;361(9375):2139-48.
10. Parashar UD, Gibson CJ, Bresee JS, Glass RI. Rotavirus and severe childhood diarrhea. *Emerg Infect Dis*. 2006;12(2):304-6.
11. Mwenda JM, Ntoto KM, Abebe A, Enweronu-Laryea C, Amina I, McHomvu J, et al. Burden and epidemiology of rotavirus diarrhea in selected African countries: preliminary results from the African Rotavirus Surveillance Network. *The Journal of infectious diseases*. 2010;202 Suppl(Supplement_1):S5-S11.
12. World Health Organization. WHO Global Invasive Bacterial Vaccine-Preventable Disease and Rotavirus and Pediatric Diarrhea Surveillance Networks Bulletin Geneva, Switzerland: World Health Organization; 2018 [cited 2019 2nd May 2019]. Available from: <https://mailchi.mp/046b8f12e001/who-ib-vpd-and-rotavirus-surveillance-bulletin-june-1566245?e=225412eff9>.
13. Tate JE, Burton AH, Boschi-Pinto C, Parashar UD, World Health Organization-Coordinated Global Rotavirus Surveillance N. Global, Regional, and National Estimates of Rotavirus Mortality in Children <5 Years of Age, 2000-2013. *Clin Infect Dis*. 2016;62 Suppl 2(suppl_2):S96-S105.
14. Ferrari MJ, Grais RF, Bharti N, Conlan AJ, Bjornstad ON, Wolfson LJ, et al. The dynamics of measles in sub-Saharan Africa. *Nature*. 2008;451(7179):679-84.
15. Brownwright TK, Dodson ZM, van Panhuis WG. Spatial clustering of measles vaccination coverage among children in sub-Saharan Africa. *BMC public health*. 2017;17(1):957.

16. Perry RT, Murray JS, Gacic-Dobo M, Dabbagh A, Mulders MN, Strebel PM, et al. Progress toward regional measles elimination—worldwide, 2000–2014. *Morbidity and Mortality Weekly Report*. 2015;64(44):1246-51.
17. Long SS, Prober CG, Fischer M. *Principles and practice of pediatric infectious diseases*. Philadelphia, USA: Elsevier Health Sciences; 2018.
18. Bloom DE, Canning D, Weston M. The value of vaccination. *WORLD ECONOMICS-HENLEY ON THAMES*-. 2005;6(3):15.
19. Ehreth J. The global value of vaccination. *Vaccine*. 2003;21(7):596-600.
20. Maurice JM, Davey S. *State of the World's Vaccines and Immunization*: World Health Organization; 2009.
21. Bennett D, Bisanzio D, Deribew A, Gething P, Hay S, Ali R. Global, regional, and national under-5 mortality, adult mortality, age-specific mortality, and life expectancy, 1970–2016: a systematic analysis for the Global Burden of Disease Study 2016. 2017.
22. Kaslow DC, Kalil J, Bloom D, Breggi G, Colucci AM, De Gregorio E, et al. The role of vaccines and vaccine decision-making to achieve the goals of the Grand Convergence in public health. *Vaccine*. 2017;35:A10-A5.
23. World health Organization. Immunization Coverage 2017 [cited 2017 1:19PM, 31st October 2017]. Available from: <http://www.who.int/mediacentre/factsheets/fs378/en/>.
24. Keja K, Chan C, Hayden G, Henderson RH. Expanded programme on immunization. *World health statistics quarterly Rapport trimestriel de statistiques sanitaires mondiales*. 1988;41(2):59-63.
25. Sultanate of Oman Ministry of Health. *Manual on Expanded Programme on Immunization*. Third Edition ed2002.
26. World Health Organization. *Vaccination Coverage Cluster Survey: Reference Manual*. Geneva, Switzerland: World Health Organization; 2018.
27. World Health Organization. *Global vaccine action plan 2011-2020*. Geneva, Switzerland: World Health Organization; 2013.
28. Wiysonge CS, Uthman OA, Ndumbe PM, Hussey GD. Individual and contextual factors associated with low childhood immunisation coverage in sub-Saharan Africa: a multilevel analysis. *PLoS One*. 2012;7(5):e37905.
29. World Health Organization. *Methodology for the Assessment of Missed Opportunities for Vaccination*. Geneva, Switzerland2017.
30. Strategic Advisory Group of Experts on Immunization (SAGE). *2018 Assessment Report of the Global Vaccine Action Plan* Geneva, Switzerland: World Health Organization; 2018.
31. Gunnala R, Ogbuanu IU, Adegoke OJ, Scobie HM, Uba BV, Wannemuehler KA, et al. Routine Vaccination Coverage in Northern Nigeria: Results from 40 District-Level Cluster Surveys, 2014-2015. *PLOS ONE*. 2016;11(12):e0167835.
32. Wandersman A, Duffy J, Flaspohler P, Noonan R, Lubell K, Stillman L, et al. Bridging the gap between prevention research and practice: The interactive systems framework for dissemination and implementation. *American journal of community psychology*. 2008;41(3-4):171-81.
33. Stokes-Prindle C, Wonodi C, Aina M, Oni G, Olukowi T, Pate M, et al. Landscape analysis of routine immunization in Nigeria: identifying barriers and prioritizing interventions. *International Vaccine Access Centre (IVAC), Johns Hopkins University School of Public Health, Bloomberg*. 2012.

34. Comprehensive EPI Multi Year Plan (2011 - 2015). Abuja, Nigeria: Federal Ministry of Health, Nigeria; 2011 2011 - 2015.
35. Nuhu A. New Vaccines Introduction in Nigeria: Catalyst for Improving Immunization Coverage and Child Survival. *Journal of Pain & Relief*. 2015;2014.
36. Sadoh AE, Nwaneri DU, Ogboghodo BC, Sadoh WE. Effect of introduction of pentavalent vaccine as replacement for Diphtheria–Tetanus–Pertussis and Hepatitis B vaccines on vaccination uptake in a health facility in Nigeria. *Vaccine*. 2016;34(24):2722-8.
37. National Primary Health Care Development Agency. The National Immunization Schedule in Nigeria Abuja, Nigeria [cited 2019 5th February 2019]. Available from: <http://nphcda.gov.ng/?ddownload=673>.
38. National Primary Healthcare Development Agency and National Bureau of Statistics. Nigeria National Immunization Coverage Survey 2016/2017, Final Report. Abuja, Nigeria: National Primary Healthcare Development Agency and National Bureau of Statistics; 2017.
39. National Primary Healthcare Development Agency and National Bureau of Statistics. Nigeria National Immunization Coverage Survey 2016/17, Final Report. Abuja, Nigeria: National Primary Healthcare Development Agency and National Bureau of Statistics; 2017.
40. WHO/UNICEF. Progress and Challenges with Achieving Universal Immunization Coverage: 2015 Estimates of Immunization Coverage. Geneva: WHO Immunization Vaccines and Biologics; 2016 2016.
41. Rainey JJ, Watkins M, Ryman TK, Sandhu P, Bo A, Banerjee K. Reasons related to non-vaccination and under-vaccination of children in low and middle income countries: findings from a systematic review of the published literature, 1999–2009. *Vaccine*. 2011;29(46):8215-21.
42. Crocker-Buque T, Mindra G, Duncan R, Mounier-Jack S. Immunization, urbanization and slums—a systematic review of factors and interventions. *BMC public health*. 2017;17(1):556.
43. Fatiregun AA, Adebawale AS, Ayoka RO, Fagbamigbe AF. Assessing full immunisation coverage using lot quality assurance sampling in urban and rural districts of southwest Nigeria. *Transactions of The Royal Society of Tropical Medicine and Hygiene*. 2013;107(11):731-40.
44. Antai D. Migration and child immunization in Nigeria: individual-and community-level contexts. *BMC public health*. 2010;10(1):116.
45. Hinman AR, McKinlay MA. Immunization equity. *Vaccine*. 2015;33:D72-D7.
46. World Health Organization. Planning guide to reduce missed opportunities for vaccination. Geneva, Switzerland: World Health Organization; 2017.
47. Hutchins SS, Jansen HA, Robertson SE, Evans P, Kim-Farley RJ. Studies of missed opportunities for immunization in developing and industrialized countries. *Bull WHO*. 1993;71(5):549-60.
48. Sridhar S, Maleq N, Guillermet E, Colombini A, Gessner BD. A systematic literature review of missed opportunities for immunization in low- and middle-income countries. *Vaccine*. 2014;32(51):6870-9.
49. Ubajaka F, Ukegbu A, Okafor N, Ejiofor O. The prevalence of missed opportunities for immunization among children utilizing immunization services in Nnamdi Azikiwe University Teaching Hospital, NNEWI. *J Biol Agric Healthcare*. 2012;2(6).
50. Anah M, Etuk I, Udo J. Opportunistic immunization with in-patient programme: eliminating a missed opportunity in Calabar, Nigeria. 2007.
51. Organization WH. Summary of the April 2016 meeting of the Strategic Advisory Group of Experts on immunization (SAGE). Geneva: World Health Organization. 2016.

52. Velandia-González M, Trumbo SP, Díaz-Ortega JL, Bravo-Alcántara P, Danovaro-Holliday MC, Dietz V, et al. Lessons learned from the development of a new methodology to assess missed opportunities for vaccination in Latin America and the Caribbean. *BMC international health and human rights*. 2015;15(1):5.
53. Nations U. The challenge of slums: global report on human settlements. Geneva: UN-HABITAT. 2003.
54. Khan M, Grübner O, Krämer A. Frequently used healthcare services in urban slums of Dhaka and adjacent rural areas and their determinants. *Journal of Public Health*. 2012;34(2):261-71.
55. Batalden PB, Davidoff F. What is “quality improvement” and how can it transform healthcare? *Quality and safety in health care*. 2007;16(1):2-3.
56. Hughes RG. Tools and strategies for quality improvement and patient safety. 2008.
57. Berwick DM. A primer on leading the improvement of systems. *BMJ: British Medical Journal*. 1996;312(7031):619.
58. Koning H, Verver JP, Heuvel J, Bisgaard S, Does RJ. Lean six sigma in healthcare. *Journal for Healthcare Quality*. 2006;28(2):4-11.
59. Kilo CM. A framework for collaborative improvement: lessons from the Institute for Healthcare Improvement's Breakthrough Series. *Quality Management in Healthcare*. 1998;6(4):1-14.
60. Lee CS, Larson DB. Beginner's guide to practice quality improvement using the model for improvement. *J Am Coll Radiol*. 2014;11(12 Pt A):1131-6.
61. Chin MH, Alexander-Young M, Burnet DL. Health care quality-improvement approaches to reducing child health disparities. *Pediatrics*. 2009;124(Supplement 3):S224-S36.
62. Leatherman S, Ferris TG, Berwick D, Omaswa F, Crisp N. The role of quality improvement in strengthening health systems in developing countries. *International Journal for Quality in Health Care*. 2010;22(4):237-43.
63. Organization WH. Global Vaccine Action Plan 2011-2020. *Global Vaccine Action Plan 2011-2020*. 2013.
64. Green L, Kreuter M, Deeds S, Partridge K. Educational diagnosis: Assessing causes of health behavior. III *Health Educational Planning-A Diagnostic Approach*. Mountain View. California, Mayfield Publishing; 1980.

Chapter 2: Prevalence and dynamics of missed opportunities for vaccination among children in Africa: Applying systems thinking in a systematic review and meta-analysis of observational studies

2.0 About this chapter

In this chapter, we report a systematic review and meta-analysis of missed opportunities for vaccination in Africa including the dynamics of associated factors. This chapter has been published by Taylor and Francis Group in *Expert Review of Vaccines* on 20th March 2019, and can be accessed through the following link: <https://doi.org/10.1080/14760584.2019.1588728> The full citation is as follows: Abdu A. Adamu, Ahmed M. Sarki, Olalekan A. Uthman, Alison B. Wiyeh, Muktar A. Gadanya & Charles S. Wiysonge. Prevalence and dynamics of missed opportunities for vaccination among children in Africa: applying systems thinking in a systematic review and meta-analysis of observational studies. *Expert Review of Vaccines* 2019; (18) 5: 547-558, DOI: [10.1080/14760584.2019.1588728](https://doi.org/10.1080/14760584.2019.1588728). Epub 2019 Mar 20.

2.1 Abstract

Objective: To estimate the prevalence of missed opportunities for vaccination (MOV) among children aged 0 – 23 months attending healthcare facilities in Africa, and also explore the dynamics of factors responsible for MOV using systems thinking.

Research design and methods: We conducted a systematic review and meta-analysis of studies that reported the proportion of eligible children who missed vaccination despite contact with health services. Studies were identified by searching five electronic databases. After selection, a random effects model was fitted to obtain pooled estimates of MOV. Then, a causal loop diagram (CLD) was constructed to explore the dynamics of factors that cause MOV.

Main outcome measure: MOV was defined as any contact with health services in Africa by an unvaccinated or under-vaccinated child aged 0 – 23 months who is eligible for vaccination and free of any contraindication which did not result in vaccination.

Results: A total of 421 publications were found, out of which 20 studies from 14 countries met our inclusion criteria. Following meta-analysis, the pooled prevalence of MOV was estimated to be 27.26% (95%CI: 18.80 – 36.62). Using factors from individual studies, a CLD with seven reinforcing and two balancing loops was constructed.

Conclusion: Our findings suggest that about one in every four children under the age of two who visited health facilities in 14 African countries missed the vaccination he or she was eligible to receive. To enable continent-wide estimates, more MOV assessments are required.

2.2 Introduction

According to the World Health Organization (WHO), a missed opportunity for vaccination (MOV) is defined as “any contact with health services by an individual (child or person of any age) who is eligible for vaccination (e.g. unvaccinated or partially vaccinated and free of contraindications to vaccination) which does not result in the person receiving one or more of the vaccines doses for which he or she is eligible” (1). It can occur during clinic visits for preventive care such as immunization and growth monitoring or curative care for injuries and ailments (2). Nevertheless, higher prevalence have been reported in curative care settings (2). In a previous review the median MOV prevalence in preventive health services was 32%, as compared to 42% in curative health services (2). MOV has been identified as an important contributor to poor childhood immunization coverage levels (2, 3). According to the World Health Organization (WHO), MOV accounts for a fraction of children who do not receive DTP3 (third dose of diphtheria-tetanus-pertussis containing vaccines) in Mozambique (14%), Uganda (11%) and Republic of the Niger (10%) (1).

The reasons for MOV are multi-faceted, involving multiple stakeholders such as caregivers, health workers and health system managers (4-8). In a health facility survey conducted in Kenya, vaccine stockout, BCG syringe stockout, child illness and underweight were reported as reasons for not vaccinating children during clinic visits (4). Researchers in Eswatini (formerly Swaziland) reported that MOV occurred more frequently among children requiring first dose of all vaccines antigens because they usually do not possess vaccination cards (5). Surprisingly, they also found that MOV was higher in healthcare facilities that offer integrated services (5).

With approximately 10 million children in Africa’s annual birth cohort remaining unvaccinated or partially vaccinated, the need to position MOV reduction as a cross-cutting health systems strengthening priority has become pertinent at district and national level (9, 10). Encouragingly, the World Health Organization has updated its strategy on MOV to focus on children aged 0 – 23 months in health service settings (11). In addition, tools and protocols for assessments have been simplified and standardized for ease of use and applicability across diverse settings (11). However, existing literature on synthesized evidence of the prevalence of MOV, which is necessary for informed decision making on the continent, has limitations.

Systematic reviews of health facility-based MOV assessment in Africa where majority of unimmunized children live are scarce (12). Previous reviews on MOV have, hitherto, combined estimates from population-based and health facility-based surveys (2, 3). Also, the age category of participants in individual studies that were considered in earlier reviews vary widely from newborns to adolescents whereas the current focus is on children less than two years of age (2, 3).

Furthermore, previous reviews have described the factors responsible for MOV using linear approaches (2, 3). Such approaches assume that factors interact with an outcome linearly to produce expected output (13). Under real world condition, the immunization sub-system can be described as a complex system both in design and number of stakeholders which can include caregivers, health workers, health facility managers and policy makers among others (13, 14). All these components interact in a nonlinear and dynamic manner to produce unexpected outputs (13). In addition, contextual factors such as resource availability and sociocultural beliefs that are at play where these systems are located constantly influence the behavior of stakeholders (15, 16). Growing literature on complexity offers new insights on how to contextualize problems from a system-wide perspective (17-19).

Against this background, we aimed to estimate the prevalence of missed opportunities for vaccination among children aged 0 – 23 months attending healthcare facilities in Africa and explore the dynamics of factors responsible for it using systems thinking. This will provide relevant evidence for health policy makers and practitioners on the continent.

2.2.1 Theoretical underpinning of systems thinking approach

Several studies have proposed useful conceptual frameworks for exploring factors that are associated with non-vaccination or partial vaccination among children (20-22). These studies have highlighted the multi-faceted nature of the determinants of suboptimal vaccination (20-22). In fact, one of the frameworks enumerated health worker-, health system-, and caregiver-related problems that can predict MOV (20). Using a complex adaptive system (CAS) theory lens in this current study, we advanced existing conceptual frameworks by elucidating how these multiple factors that are associated with MOV potentially interact with each other (23). CAS theory offers a way of making sense of phenomena that are dependent upon the behavior of various

stakeholders and their responses (24). The advantage of viewing a problem through this lens is that it accounts for the variation in the degree of influence of stakeholders and the unpredictability of their behaviors (25). In addition, it recognizes the dynamical interactions and synergies that occur continuously among multiple factors (25). Applying this theory provides further insights into leverage points within the systems that can guide the prioritization of innovative solutions. To conceptualize the dynamic architecture of the factors that cause MOV among children within an Africa context, a causal loop diagram (CLD) was employed (26). This was to enable an explicit visual illustration of the relationship between these variables (26). Some of the key elements of causal loop diagrams include causality, delays, polarity, and feedback loops which can either be reinforcing or balancing (27).

2.3 Methods

2.3.1 Protocol and registration

A protocol that pre-specified the objectives and methodology including eligibility criteria was developed in advance and registered on PROSPERO with ID number: CRD42018098736 (<https://www.crd.york.ac.uk/PROSPERO/>). This systematic review was reported according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline (28).

2.3.2 Eligibility criteria

We included surveys conducted in health facilities regardless of location characteristics (rural or urban) that reported the proportion of children aged 0 – 23 months who remained unvaccinated or under-vaccinated despite contact with health services in Africa. The eligibility criteria are summarized on **Table 2.1**.

Table 2.1: Pre-specified eligibility criteria for including and excluding observational studies on burden of missed opportunities for vaccination in Africa

Characteristics	Inclusion Criteria	Exclusion Criteria
Population	Children aged 0 - 23 months of age	Other populations such as adolescents
Outcome	Missed opportunities for vaccination: by vaccine and vaccine dose. Missed opportunities for vaccination (MOV) is defined as "any contact with health services in Africa by an unvaccinated or under-vaccinated child aged 0 – 23 months who is eligible for vaccination and free of any contraindication which does not result in vaccination"	Missed opportunities for prophylactic antibiotics
Study type	Facility based surveys regardless of study design.	Population based surveys
Context	Health care facilities (primary, secondary or tertiary) within Africa	

2.3.3 Information sources

Electronic database

To identify relevant publications, a comprehensive and systematic search of electronic databases was performed. A total of five electronic databases were searched on the internet and they include MEDLINE (via Pubmed), Scopus, Google Scholar, African Index Medicus, and WHO Institutional Repository for Information Sharing (IRIS). No date, document format or language restriction was specified. Search terms comprising of free text and medical subject headings (MeSH) were used in querying all the electronic databases. The search terms included: “immunization”, “vaccination”, “missed opportunities”, “children”, “childhood”, “prevalence”, “burden”, “epidemiology”, “Africa”, and “sub-Saharan Africa”. A detailed search strategy was

developed for Pubmed and adapted for the other databases. See **Supplementary Material 2.1** for detailed search strategy. The last database search was conducted on 21st November 2018. Since Google yields high search volume, we limited search to the first 250 results (29).

Other sources

Focal persons from WHO and MOV partner organizations including United Nations Children's Fund (UNICEF), United States Centers for Disease Control and Prevention (CDC), Medecins Sans Frontieres (MSF), John Snow Inc (JSI), Agency de Medecine Preventive (AMP), Village Reach, Clinton Health Access Initiative (CHAI), Gavi – the vaccine alliance, and Bill and Melinda Gates Foundation (BMGF) were contacted for any unpublished manuscripts or grey literature on MOV assessments in Africa. Finally, we searched the reference list of relevant articles to identify publications that were not indexed on the databases.

2.3.4 Study selection

Three authors (AAA, ABW and AMS) screened the titles and abstracts of all the publications obtained from databases for relevance. Then, they independently assessed the full text of relevant studies against the eligibility criteria. During this process, disagreements were resolved through discussion.

2.3.5 Data collection process

A data extraction sheet was developed using Microsoft Excel 2016. The tool was pilot tested with five randomly selected studies which informed some minor refinement. Data extraction was performed by two authors (ABW and AMS) and disagreements were resolved by discussion.

2.3.6 Data items

The data that were extracted from each included study are as follows: Study title, year of publication, surname of first author, affiliated institution(s) of first author, country of assessment, level of healthcare (primary/secondary/tertiary), sample size of children aged 0 – 23 months, number of children who missed vaccines or vaccines doses among children aged 0 – 23 months during facility visit, proportion of MOV, sampling strategy, location characteristics of health

facilities, means of assessing vaccination status, number of health facilities, and factors associated with MOV. Additional information about geographical region (using United Nations “standard country or area codes for statistical use”) and WHO regions; Regional Office for Africa (AFRO) and Regional Office for the Eastern Mediterranean (EMRO) were added.

2.3.7 Risk of bias in individual studies

The Risk of Bias Assessment tool for Non-randomized Studies (RoBANS) and ACROBAT-NRSI (“A Cochrane Risk Of Bias Assessment Tool for Non-Randomized Studies”) (see **Box 2.1**) was adapted and used in this review (30, 31). The risk of bias was assessed by scoring (low risk = 1, unclear = 0, high risk = -1) each bias type for each publication and the total score was used as the summary assessment of risk of bias.

Box 2.1: Risk of bias assessment			
Bias type	Low risk of bias	High risk of bias	Unclear risk of bias
Selection (sample population)	participants selected randomly	Sample selection ambiguous and sample unlikely to be representative	Insufficient information
Selection (participation rate)	High participation rate (>70-85%)	Low participation rate (<70%)	Insufficient information
Performance bias (outcome assessment)	Objective measures of MOV (i.e. health records / cards)	Self-reported measure of MOV	Insufficient information
Performance bias (analytical methods to control for bias)	Analysis appropriate for type of sample (unadjusted, univariable analyses etc.)	Analysis does not account for common adjustment (adjusted, multivariable analyses)	Insufficient information

Other form of bias	There is no evidence of bias from other sources.	There is potential bias present from other sources	Insufficient information
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2.3.8 Summary measure

The summary measure that was computed is proportion of missed opportunities for vaccination. This was defined as the number of children aged 0 – 23 months who remained unvaccinated or under-vaccinated despite contact with health services divided by total number of children aged 0 – 23 months attending health facility.

2.3.9 Data analysis

To estimate the prevalence of missed opportunities for vaccination among children aged 0 – 23 months attending healthcare facilities in Africa.

To compute the summary effect size, first, proportions that were extracted from individual studies were transformed using the Freeman-Tukey double arcsine transformation method (32). This was to avoid skewness as the proportion of MOV was reported to be zero in one of the study (33). The transformation serves to stabilize the variance thus enabling transformed proportions to approximate a normal distribution (32). Then, the normalized proportions and their asymptotic variances were used to compute the pooled estimate. Dersimonian and Laird random effects model was fitted using number of children who missed vaccination (r) and total sample size of children (n) to obtained the pooled prevalence of MOV for each geographical region and Africa (34). In the model, study specific confidence limits for the pooled estimate was constructed using Clopper-Pearson method (exact method) (35). Stata ‘metaprop’ package was used to perform this meta-analysis (36). Heterogeneity across studies was calculated and I^2 was obtained (37). To explore the heterogeneity, potential effect modifiers were considered in univariable meta-regression analysis. These include study characteristics such as year of publication, geographical region, WHO region, sampling strategy, sample size, number of health facilities, location characteristics, and means of assessing vaccination status. To check for bias, a funnel plot was constructed (38). Then Egger’s test was performed with included studies to

explore for publication bias (39). In addition, a contour-enhanced funnel plot was constructed (40). Meta-analysis results were reported as pooled prevalence with 95% confidence intervals (CIs), while meta-regression results are reported as odds ratio with 95% CIs. All analyses were performed in Stata 14.2.

To identify factors associated with missed opportunities for vaccination among children aged 0 – 23 months attending healthcare facilities in Africa.

Factors were extracted from the included studies and then categorized into three themes as follows: health service-related factors, caregiver/parents related factors, and health workers related factors. The authors brainstormed on the identified factors before using them to build a causal loop diagram (CLD). AAA constructed the CLD. While CSW, OAU, MAG, ABW, ASM and AAA validated the diagram. The validation was done by manually assessing the structure of the diagram and proposed linkages (41). The linkages were assessed for clarity and plausibility. Disagreements were resolved through discussions.

To describe the dynamics of identified factors and their relationship with missed opportunities for vaccination.

Variables were linked using arrows (———▶) to denote the direction of influence. If the influence is in the same direction, a positive (+) polarity is used, otherwise, a negative (-) polarity is indicated. In the diagram, we termed closed cycles as balancing feedback loop (denoted with B) if the effect of a change in the variables results in a counter change in the opposite direction, and reinforcing feedback loop (denoted with R) if the effect of a change in the variables within the loop will propagate more change in the same direction. CLD was built with Vensim PLE x32 (42).

2.4 Result

2.4.1 Characteristics of included studies

A total of 421 publications; 102 from Pubmed, 69 from Scopus, and 250 from Google Scholar were retrieved. Upon removing duplicates, 366 studies were left. An additional 312 studies that were not relevant to our study were removed. A total of 54 full text articles were selected for

critical reading. Finally, 20 studies (three in French language) conducted across different levels of healthcare were included in this review (4, 5, 7, 33, 43-58). The study selection process for this systematic review is presented on the PRISMA flow chart in **Figure 2.1**.

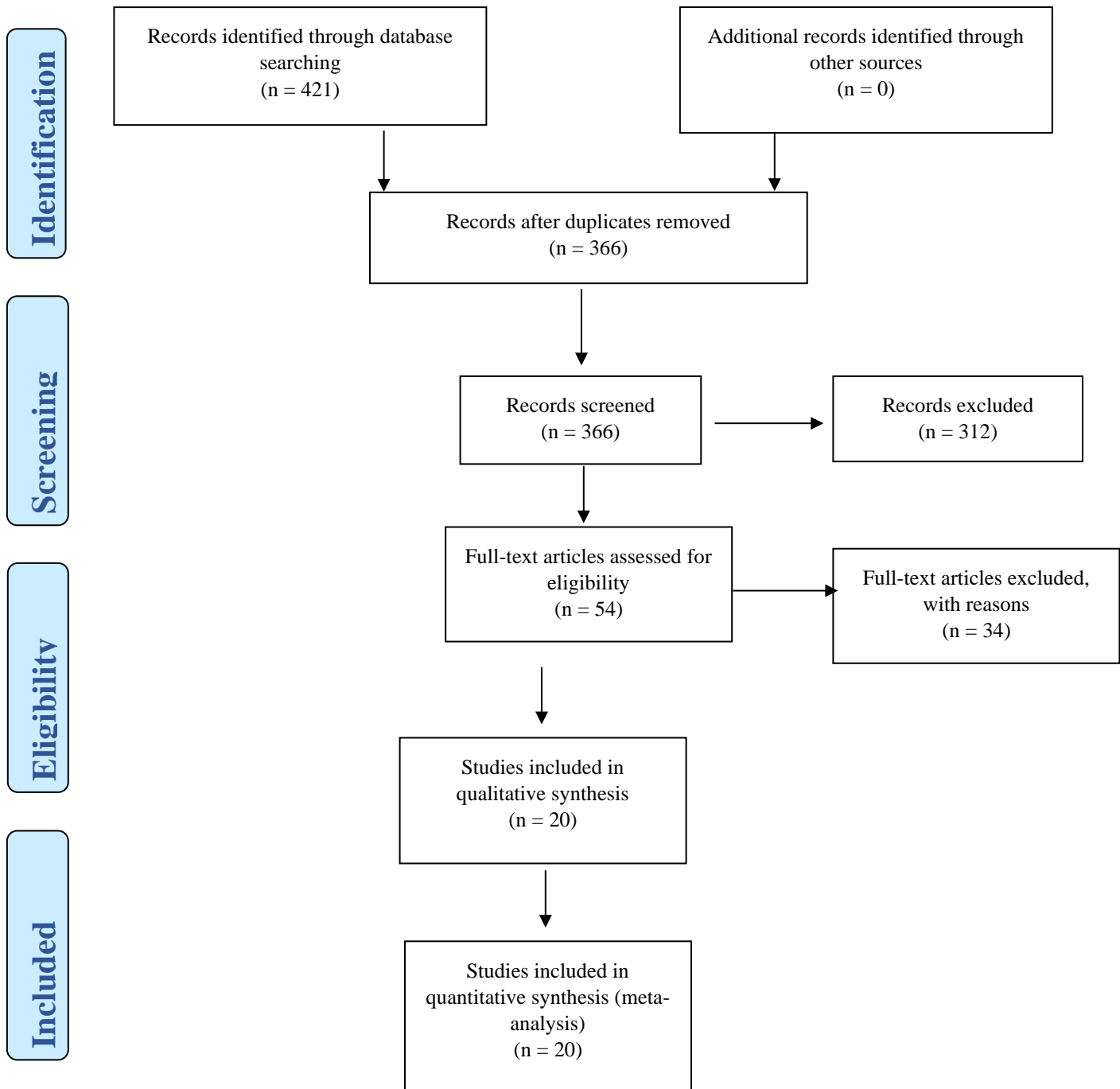


Figure 2.1: PRISMA Flow chart

No unpublished manuscripts or reports were received. To avoid double counting, a thesis was excluded since it had also been published as a manuscript (51). The included studies involved 6030 children under two years of age from 14 countries and were published between 1989 and 2017 as shown in **Figure 2.2**.

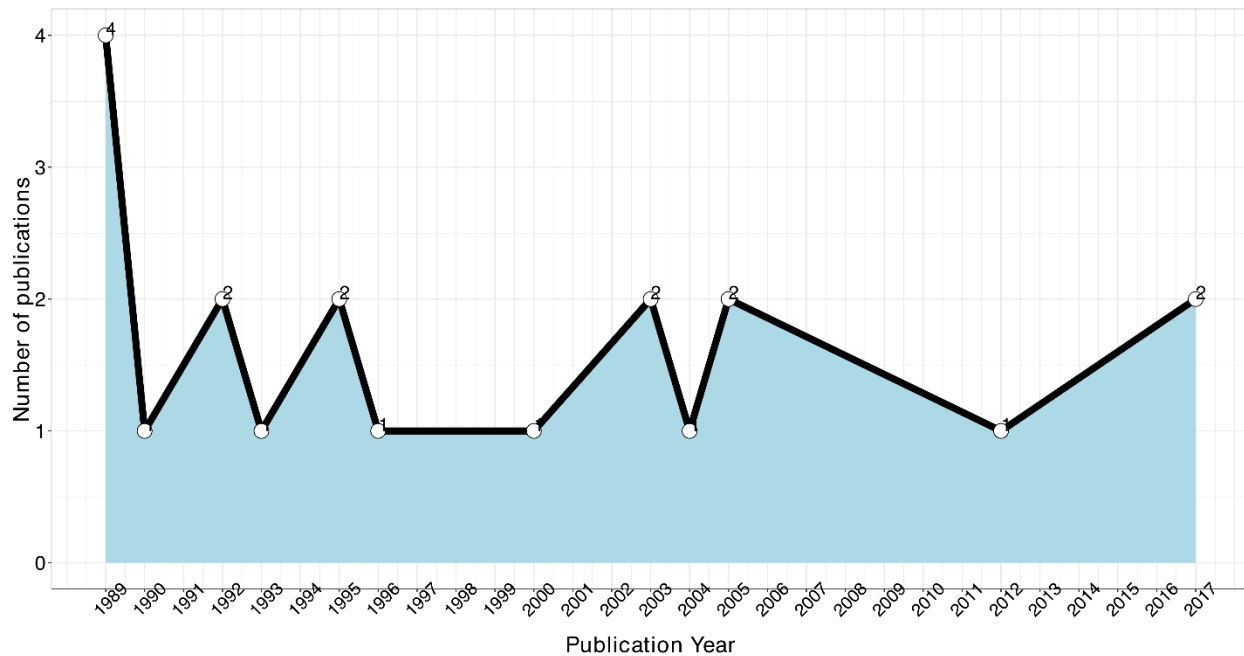


Figure 2.2: A line graph of published studies on MOV in Africa

The countries are distributed across both WHO regions (EMR, 5; AFR, 15) on the continent. Sudan and Egypt are countries on the African continent that are in the EMR. The number of MOV assessments were highest in Sudan and Nigeria. Other characteristics of included studies are on **Table 2.2**.

Table 2.2: Characteristics of studies that assessed the prevalence of missed opportunities for vaccination among children aged 0 – 23 months in health facilities in Africa

S/No	Study ID	First Author	Country	Geographic Region (United Nations classification)	Definition of MOV	Number of health facilities	Year of MOV Assessment	Location Characteristics	Level of healthcare	Means of assessing vaccination status
1	MOV001	Borus (2004)	Kenya	Eastern Africa	"Missed immunisation opportunities were assessed as a proportion of age-eligible children who were attended to at surveyed health facilities for various reasons"	6	2001	Urban	Mixed	Combined vaccination cards and self reporting
2	MOV002	Brugha (1995)	Ghana	Western Africa	"Failure to receive all the immunizations for which they were eligible on at least one visit to an under-fives clinic"	3	Not clear	Rural	Secondary	Combined vaccination cards and self reporting
3	MOV003	Daly (2003)	Eswatini (Previously Swaziland)	Southern Africa	"Any child who was not up to date, lacked appropriate contraindications, or whose caretaker had not refused the vaccination, was considered a missed opportunity"	34	1997	Mixed	Primary	Combined vaccination cards and self reporting

S/No	Study ID	First Author	Country	Geographic Region (United Nations classification)	Definition of MOV	Number of health facilities	Year of MOV Assessment	Location Characteristics	Level of healthcare	Means of assessing vaccination status
4	MOV004	Dawria (2017)	Sudan	Northern Africa	"When a child who is eligible for immunization and who has no contraindications to immunization visit a health service and doesn't receive the vaccine"	1	2016	Urban	Tertiary	Combined vaccination cards and self reporting
5	MOV005	Dyer (1993)	South Africa	Southern Africa	"When a child came to a health facility and, in the absence of any contraindication, did not receive any or all the vaccine doses for which he or she was eligible"	24	1991	Mixed	Mixed	Combined vaccination cards and self reporting
6	MOV006	Hipgrave (1992)	Malawi	Eastern Africa	"Children less than 23 months having an incomplete immunisation schedule, after seen by a health worker at a facility where vaccination is available , and yet leave without being immunised"	12	Not clear	Rural	Mixed	Combined vaccination cards and self reporting
7	MOV007	Loevinsohn (1989)	Sudan	Northern Africa	"Children coming to urban health facilities need vaccinations but are not receiving them"	11	Not clear	Urban	Mixed	Combined vaccination cards and self reporting

S/No	Study ID	First Author	Country	Geographic Region (United Nations classification)	Definition of MOV	Number of health facilities	Year of MOV Assessment	Location Characteristics	Level of healthcare	Means of assessing vaccination status
8	MOV008	Loevinsohn (1992)	Sudan	Northern Africa	"Children coming to urban health facilities need vaccinations but are not receiving them"	12	Not clear	Urban	Mixed	Combined vaccination cards and self reporting
9	MOV009	McCormick (1996)	Zimbabwe	Eastern Africa	"When a woman or child who is eligible for vaccination visits a health facility but fails to receive that vaccination"	4	1995	Urban	Mixed	Self reported
10	MOV010	Tagbo (2005)	Nigeria	Western Africa	"If a child visits a health facility and did not receive the vaccination for which he or she was eligible"	1	Not clear	Urban	Tertiary	Combined vaccination cards and self reporting
11	MOV011	Ubajaka (2012)	Nigeria	Western Africa	"A situation whereby a child visited a health facility and did not receive vaccine(s) for which he or she was eligible"	1	2010	Urban	Tertiary	Combined vaccination cards and self reporting
12	MOV012	WHO (1989)	Egypt	Northern Africa	"Failure to immunize a child whose immunization status is not up-to-date and who has no contraindications is considered a missed opportunity"	1	1988	Rural	Secondary	Combined vaccination cards and self reporting

S/No	Study ID	First Author	Country	Geographic Region (United Nations classification)	Definition of MOV	Number of health facilities	Year of MOV Assessment	Location Characteristics	Level of healthcare	Means of assessing vaccination status
13	MOV013	WHO (1990)	Ethiopia	Eastern Africa	"eligible children in need of immunization who left the health facility without receiving the needed immunization"	9	1988	Mixed	Mixed	Combined vaccination cards and self reporting
14	MOV014	WHO (1989)	Zimbabwe	Eastern Africa	"Due or overdue for immunization without contraindication and not immunized at clinic"	2	1987	Mixed	Mixed	Not indicated
15	MOV015	Malual (2017)	South Sudan	Eastern Africa	Definition not stated	1	2012	Urban	Tertiary	Combined vaccination cards and self reporting
16	MOV016	Talani (2000)	Congo	Middle Africa	"Failure to vaccinate a child, in consultation at a health facility, who does not have any contraindication to vaccination and who returns home without having received all the doses for which he is eligible"	10	1998	Not Indicated	Not clear	Vaccination card
17	MOV017	Josse (1989)	Benin	Western Africa	Definition not stated	7	1989	Urban	Not clear	Vaccination card

S/No	Study ID	First Author	Country	Geographic Region (United Nations classification)	Definition of MOV	Number of health facilities	Year of MOV Assessment	Location Characteristics	Level of healthcare	Means of assessing vaccination status
18	MOV018	Fermon (1995)	Republic of the Niger	Western Africa	"The target population (incompletely vaccinated women and children) visits a health facility offering vaccination, and does not receive not the required vaccine(s) (in the absence of any contraindication)"	5	1992	Urban	Mixed	Not stated
19	MOV019	Himat (2003)	Sudan	Northern Africa	"An opportunity for immunization is missed when a person who is eligible for immunization and who has no contraindication to immunization visits a health service and does not receive all the needed vacancies" "Missed opportunity is when a child who needed an immunization had contact with the health service but was not given the vaccination"	11	2003	Mixed	Mixed	Combined vaccination cards and self reporting
20	MOV020	Onyiriuka (2005)	Nigeria	Western Africa		1	2003	Urban	Secondary	Combined vaccination cards and self reporting

2.4.2 Risk of bias of included studies

Based on sample selection, 4 out of 20 studies were assessed as having low risk, and risk was unclear in 8 studies thus yielding a score of -4. Participation rate was classified low risk in 17 studies and unclear in 3, hence, a score of 17. Analysis was appropriate for type of sample across studies, thus yielding a score of 20. Detailed assessment of risk of bias for each of the included studies is shown in **Box 2.2**.

Box 2.2: Risk of bias analysis of studies included the systematic review

		Selection		Performance bias		Others
Study ID	Author(Year)	sample population	participation rate	outcome assessment	Analytical methods to control for bias	Other form of bias
MOV001	Borus (2004)	High risk	Low risk	Low risk	Low risk	Low risk
MOV002	Brugha (1995)	Unclear risk	Low risk	Low risk	Low risk	Low risk
MOV003	Daly (2003)	High risk	Low risk	Low risk	Low risk	Low risk
MOV004	Dawria (2017)	High risk	Low risk	Low risk	Low risk	Low risk
MOV005	Dyer (1993)	Low risk	Low risk	Low risk	Low risk	Low risk
MOV006	Hipgrave (1992)	Unclear risk	Low risk	Low risk	Low risk	Low risk
MOV007	Loevinsohn (1989)	Low risk	Low risk	Low risk	Low risk	Low risk
MOV008	Loevinsohn (1992)	Low risk	Low risk	Low risk	Low risk	Low risk
MOV009	McCormick (1996)	High risk	Low risk	High risk	Low risk	Low risk
MOV010	Tagbo (2005)	High risk	Low risk	Low risk	Low risk	Low risk
MOV011	Ubajaka (2012)	Low risk	Low risk	Low risk	Low risk	Low risk
MOV012	WHO (1989)	Unclear risk	Low risk	Low risk	Low risk	Low risk
MOV013	WHO (1990)	Unclear risk	Low risk	Low risk	Low risk	Low risk
MOV014	WHO (1989)	Unclear risk	Low risk	Low risk	Low risk	Low risk
MOV015	Malual (2017)	High risk	Low risk	Low risk	Low risk	Low risk
MOV016	Talani (2000)	Unclear risk	Unclear risk	Low risk	Low risk	Low risk
MOV017	Josse (1989)	Unclear risk	Unclear risk	Unclear risk	Low risk	Low risk
MOV018	Fermon (1995)	Unclear risk	Unclear risk	Low risk	Low risk	Low risk
MOV019	Himat (2003)	High risk	Low risk	Low risk	Low risk	Low risk
MOV020	Onyiriuka (2005)	High risk	Low risk	Low risk	Low risk	Low risk

2.4.3 Prevalence of missed opportunities for vaccination in Africa

The prevalence of missed opportunities for vaccination ranged from 0% (95%CI: 0.00 – 4.74) in Zimbabwe to 64.07% (95%CI: 58.04 – 69.80) in Sudan. Prevalence of MOV by geographical region are as follows: Western Africa [20.02% (95%CI: 15.87 – 24.53)], Eastern Africa [18.92% (95%CI: 4.43 – 40.16)], Southern Africa [39.38% (95%CI: 34.45 – 44.41)] and Northern Africa [46.99% (95%CI: 32.82 – 61.41)]. The overall random pooled prevalence on MOV among children aged 0 – 23 months in African health facility-based surveys is 27.26% (95%CI: 18.80 – 36.62). The variation in effect size that is attributable to heterogeneity (I^2) is 98.36%. **Figure 2.3** is a forest plot of the prevalence of MOV for 20 studies conducted in Africa.

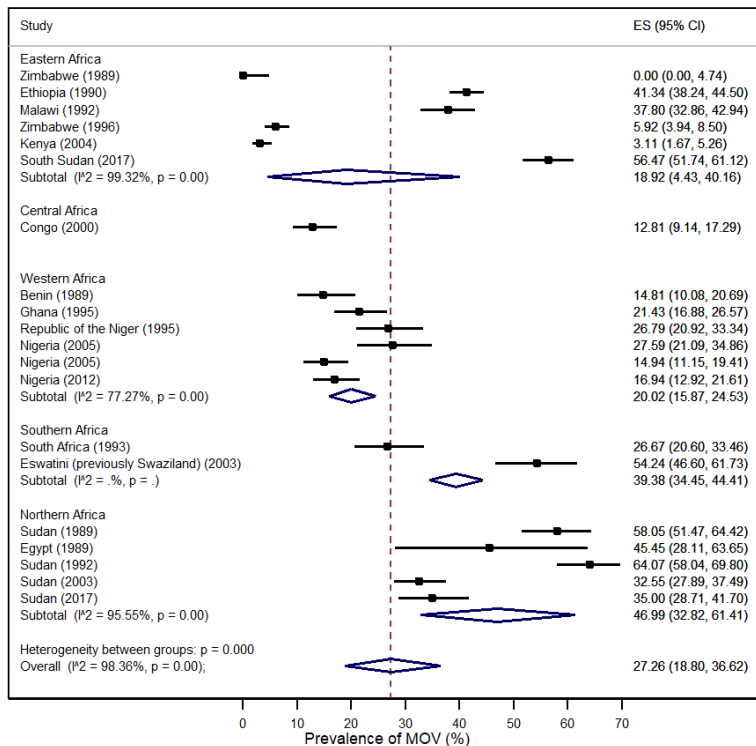


Figure 2.3: Forest plot of pooled prevalence of missed opportunities for vaccination among children aged 0 – 23 months in Africa from random-effects meta-analysis

Following univariable meta-regression analysis of study characteristics, it was found that the WHO region where the study was conducted had an unadjusted odds ratio (OR) of 3.12 (95%CI: 1.10 – 8.83) with p-value of 0.03. The unadjusted OR and p-value for other study characteristics are presented on **Table 2.3**.

Table 2.3: Unadjusted Odds ratios of study characteristics from published MOV assessments in Africa

Study characteristics	Odds Ratio	95%CI	p-Value
Year of publication	0.99	0.93 - 1.05	0.69
Geographical region	1.32	0.91 - 1.92	0.14
WHO region	3.12	1.10 – 8.83	0.03
Sampling strategy	1.03	0.48 - 2.14	0.93
Number of health facilities	1.04	0.98 - 1.10	0.22
Characteristics of location	1.32	0.67 - 2.59	0.40
Means of assessing vaccination status	1.67	0.86 – 3.22	0.12
Sample size	1.00	0.99 - 1.00	0.71

The funnel plot for estimates obtained in this study appeared asymmetrical. Following Egger's test, the estimated bias coefficient was -9.66 (95%CI: -16.87 - -2.45) with standard error of 3.42 and p-value of 0.012 thus providing evidence of small study effects. In the contour enhance funnel plot shown in **Figure 2.4**, studies appear to be missing in areas of low statistical significance thus suggesting presence of publication bias.

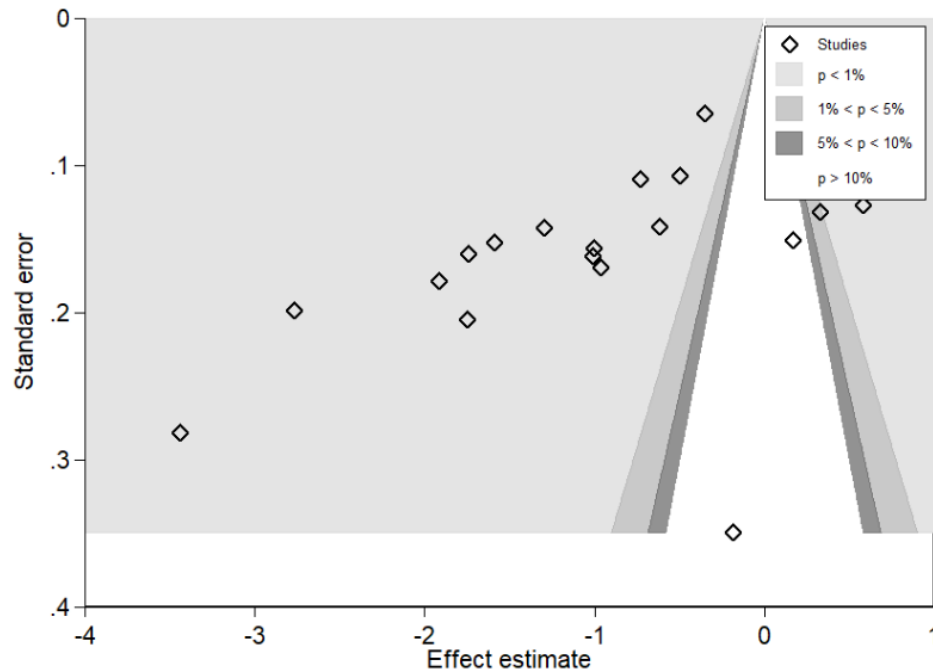


Figure 2.4: Contour-enhanced funnel plot of individual studies

2.4.4 Dynamics of missed opportunities for vaccination

Of the 20 studies included in this review, 18 reported factors responsible for missed opportunities for vaccination. Using data extracted from individual studies, a causal loop diagram of these factors was constructed. We found seven reinforcing loops and two balancing loops. The first reinforcing loop (R1) depicts the direct relationship between health services and missed opportunities, while the second reinforcing loop (R2) shows the interplay between availability of commodities in health facilities and missed opportunities. Other loops are shown below in **Figure 2.5**.

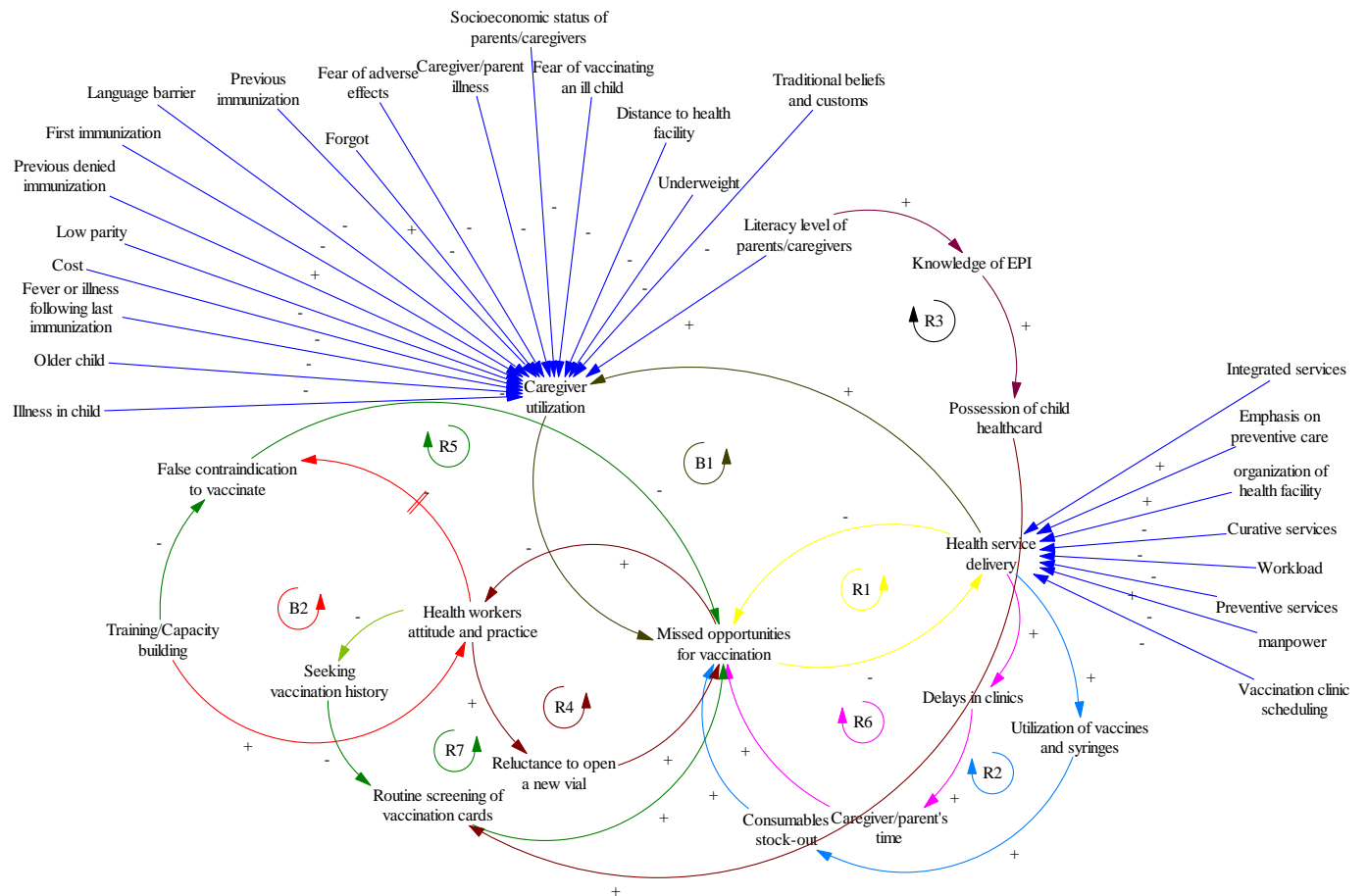


Figure 2.5: Causal loop diagram of factors associated with missed opportunities for vaccination

2.5 Discussion

2.5.1 Main findings

This study advances current knowledge on missed opportunities for vaccination in Africa. The overall pooled prevalence of MOV was found to be 27.26% (95%CI: 18.80 – 36.62). To the best of our knowledge, this is the first systematic review to compute the prevalence of MOV among children aged 0 – 23 months on the continent. In addition, this review focused on health facility-based surveys. The study also explored regional difference in MOV prevalence. Furthermore, elements of complexity was innovatively used within the framework of a systematic review to explore the dynamics of missed opportunities for vaccination in Africa. Causal loop diagram was used to illustrate the interrelationships between variables including feedbacks and delays. In our diagram, seven reinforcing loops and two balancing loops were identified.

2.5.2 Limitations and strengths of the study

Our findings should be interpreted bearing in mind the limitations and strengths of this study. The included studies span almost threedecades, from 1989 to 2017, which we consider to be a limitation. There would have been several changes to national immunization policies between those years. Also, the publications obtained are not representative of the countries as they were conducted in specific communities within the countries. Although we would have conducted a subgroup analysis to stratify by time period, only 20 studies were found. Due to this paucity of data, we had to be cautious so as not to produce estimates that might be misleading. In this study, we use a comprehensive and systematic search strategy, but we cannot conclude that all relevant publications were retrieved. Only 20 studies covering 14 out of the 54 countries in Africa were found. Even though subregions within the continent were represented, the findings should still be interpreted with caution. Also, we observed high heterogeneity (I^2 of 98.36%) that was in part explained by the variation in WHO regions (Africa and Eastern Mediterranean). As a systematic review of observational studies that included surveys from multiple countries, heterogeneity is to be expected. It is likely that some factors or links might be missing in the CLD. This is especially important as we relied on published literature as our source of information. Also, as a conceptual

tool, the direction of causality and polarity are mostly based on the experiences of the authors. As a result, authors from different contexts might not necessarily replicate the same diagram. A key strength of this study is that it was conducted in accordance with a standardized systematic review guideline. Our search included both published and unpublished literature. Also, five electronic databases were searched with no date or language restrictions. We predefined our eligibility criteria and three reviewers used it to rigorously assess included studies. In addition, we transformed the proportions that were extracted from individual studies to avoid skewing our estimates. Another key strength of this study is that we used complex adaptive systems lens to enhance the description of the factors that are associated with MOV. This guided our interpretation of how the variables interrelate thus accounting for underlying complexity. Primary studies that are included in systematic reviews are a good source of data on moderators. Using causal loop diagrams to explicitly describe these factors within the context of a systematic review is a novel approach, which further broadens the applications of systems thinking.

2.5.3 MOV in Africa

African states, alongside other WHO-member countries in 2012, endorsed the Global Vaccine Action Plan (GVAP) which aims to achieve 90% national immunization coverage and 80% immunization coverage at district level, among other targets, by 2020 (59). To support implementation efforts within the African region, a Regional Strategic Plan for Immunization 2014 – 2020 was developed (60). Furthermore, in 2016, African countries reiterated their commitment to universal access to immunization within the framework of the sustainable development goals (SDG). However, the performance of immunization systems on the continent remained suboptimal (61). So far, only 18 countries have met the GVAP target of 90% national immunization target (9). According to the 2017 assessment report of GVAP, immunization coverage in the African region, at 74%, was lowest in the world (61).

Although several activities to improve immunization coverage are being implemented in various countries across the continent, health facility-based efforts receive less attention. Therefore, children who are eligible for vaccination often make contact with health services and exit without receiving the vaccine(s) or vaccine dose(s) for which they are due, thus resulting in missed opportunities for vaccination. Our study confirmed this, as we found that about 1 in 4

children aged 0 – 23 months in 14 African countries were missed for vaccination in healthcare settings. The estimate we obtained in our study is lesser than MOV estimates for low- and middle-income countries [32.2% 95%CI (26.8 – 37.7)] most likely because we limited our age group to only children less than two years as recommended in the updated MOV methodology (1, 3).

Home-based records (HBR) play an important role in MOV assessments (1). It enables accurate quantification of the number of children who missed vaccination, as opposed to caregiver recall. Accordingly, in the updated MOV assessment methodology, immunization history that is obtained from HBR or any temporary immunization document is recommended (1). In this review, we found that majority of the studies assessed vaccination status using a combination of HBR and recall. To further improve the accuracy of assessments, there is a need to adhere to the updated MOV methodology.

This study presented a conceptual diagram that proposed the direction of relationship for several caregiver, health worker and health systems factors that cause MOV. Loop R1 indicates that an increase in health service delivery will decrease missed opportunities for vaccination, and in turn, an increase in the number of children being immunized upon contact with health services will impact on health services as this can strain resources. In loop R2 we postulate that an increase in health services delivery will increase the utilization of vaccines and syringes in clinics (if there is no commensurate increase in resources), and thus lead to stock-out of these consumables thereby increasing missed opportunities for vaccination. Loop R3 shows that increased literacy level among caregivers is likely to increase knowledge of expanded programme on immunization (EPI) which can in turn improve caregiver possession of vaccination cards to enable routine screening during clinic or hospital visits.

Reluctance to open new vials of vaccines stemming from poor attitude and practices among health workers can increase missed opportunities for vaccination as shown in loop R4. In addition, information about MOV in a clinic can improve health workers attitude and practice toward immunization. Targeted training and capacity building in clinics and hospitals can reduce the level at which health workers fail to vaccinate as a result of false contraindication, which can then reduce missed opportunities for vaccination as shown in loop R5. An increase in health service delivery can result in missed opportunities for vaccination through clinic delays and

increase in time spent by caregivers in clinic as shown in loop R6. Loop R7 show that poor attitude and practice of health workers towards immunization can decrease the level of attention given to vaccination history among children, which will further decrease the frequency of routine vaccination card screening in clinics thereby worsening missed opportunities for vaccination.

Loop B1 indicates that increased health service delivery will result in better confidence in the system thus increasing caregiver utilization and subsequently reducing missed opportunities for vaccination. Training and capacity building programmes can improve the attitude and practice of health workers involved in immunization services, and this can reduce non-vaccination due to false contraindication in loop B2. Some leverage points for interventions include routine screening of vaccination cards (R7), addressing false contraindication to vaccinate (R5), preventing reluctance to open new vial (R4), preventing consumable stock-out (R2) and reducing clinic delay (R6) among others were identified.

Several factors that can influence caregiver utilization of immunization services were depicted. Those that improve utilization include literacy level of caregivers, low parity and previous immunization in the child. While factors such as illness in the child, older child, fever or illness following last immunization, cost (transportation to health facility or service charges), when a caregiver was previously denied immunization, first immunization, language barrier with health workers, forgot about child's immunization, fear of adverse effects, when the caregiver is ill, low socioeconomic status, fear of vaccinating an ill child, distance to health facilities, having an underweight child, and traditional beliefs and customs can all reduce utilization. Also, the dynamics of factors that affect level of health service delivery were shown. Those that can increase level of health service delivery include integration of services, emphasizing preventive care in clinics, provision of preventive services. While those that can reduce service delivery include curative services, workload, manpower and vaccination clinic scheduling.

This research has implications for policy and practice. The study provided additional evidence regarding the magnitude of MOV among children aged 0 – 23 months in Africa. However, only 20 studies met the inclusion criteria. Considering the diverse settings on the continent, more context-specific surveys that focuses on this age group is required. The occurrence of MOV in health services setting within Africa is unacceptable given the low immunization coverage in the general population. Decision makers at regional and national level need to emphasize tailored

strategies to address MOV in broader health sector plans so as to maximize the use of existing health facilities for the provision of immunization services.

The causal loop diagram illustrated the dynamics of factors responsible for missed opportunities for vaccination. The diagram shows potential leverage points that can be useful for designing facility-based interventions including quality improvement interventions. Given that multiple stakeholders were identified, innovative, facility-generated solutions that targets them concurrently might be useful.

Our research recommendations are presented in **Box 2.3** using the evidence, population, intervention, comparison, outcome, time stamp EPICOT+ format (62).

Box 2.3: Use of EPICOT+ framework to recommend future primary studies on MOV assessment in Africa

Element	Recommendation(s)
	Core elements
Evidence (State of evidence)	Only systematic review included 20 studies from 14 African countries were found.
Population (Population of interest)	MOV assessments using WHO's updated methodology should be used across multiple contexts in Africa as follows: <ul style="list-style-type: none"> - Children aged 0 – 23 months (with analysis disaggregated by age group: 0-11 and 12-23 months) - Children attending specialized clinics for HIV, sickle cell disease etc. - Children in conflict affected areas - Children living in slum and non-slum urban areas
Interventions	Based on our findings we recommend small tests of change that focus on some of the leverage points identified in our CLD through; <ul style="list-style-type: none"> - Facility-based quality improvement projects for addressing MOV - Collaborative quality improvement projects with multiple facilities to address MOV.
Comparisons	Control health facilities
Outcomes	Proportion of MOV defined as the number of eligible

	children aged 0 – 23 months who missed vaccination (by vaccines and vaccine doses) divided by total number of children aged 0 – 23 months attending health facility who were eligible for vaccination.
Time stamp	January 2018
Study type	<p>Optional element</p> <p>For MOV Assessments: Cross sectional studies employing multilevel analysis approach to account for the independent influence of individual and contextual factors that can determine MOV.</p> <p>For interventions: Quasi experimental studies</p>

2.6. Conclusion

In conclusion, this study provided an estimate of the prevalence of MOV among children aged 0 – 23 months based on primary studies from 14 African countries. The findings suggest that about one in every four children under the age of two who visit health facilities miss the opportunity to receive immunization services in these countries. This indicates that efforts to address MOV within health service settings in these countries can considerably improve immunization coverage. To enable continent-wide estimates, more MOV assessments are required. In addition, the interrelationships depicted in the CLD enhanced the understanding of factors and revealed leverage points for interventions.

2.7 Competing interest

None declared

2.8 Author contribution

AAA conceptualized the study, developed the protocol, performed literature search, conducted data analysis and interpretation of results, wrote the first draft, reviewed and edited subsequent drafts. AMS and ABW participated in screening, data extraction, data analysis and manuscript

review. CSW, OAU, MAG supervised the study, reviewed and contributed to protocol development, manuscript draft, interpretation of results, and were responsible for the final approval of the manuscript. All authors read and approved this manuscript.

2.9 References

1. World Health Organization. Methodology for the Assessment of Missed Opportunities for Vaccination. Geneva, Switzerland 2017.
2. Hutchins SS, Jansen HA, Robertson SE, Evans P, Kim-Farley RJ. Studies of missed opportunities for immunization in developing and industrialized countries. *Bull WHO*. 1993;71(5):549-60.
3. Sridhar S, Maleq N, Guillermet E, Colombini A, Gessner BD. A systematic literature review of missed opportunities for immunization in low- and middle-income countries. *Vaccine*. 2014;32(51):6870-9.
4. Borus P. Missed opportunities and inappropriately given vaccines reduce immunisation coverage in facilities that serve slum areas of Nairobi. *East African medical journal*. 2004;81(3):124-9.
5. Daly AD, Nxumalo MP, Biellik RJ. Missed opportunities for vaccination in health facilities in Swaziland. *South African medical journal = Suid-Afrikaanse tydskrif vir geneeskunde*. 2003;93(8):606-10.
6. Bachmann MO, Barron P. Missed opportunities for immunisation in curative and preventive services in a community health centre. A follow-up survey. *South African medical journal = Suid-Afrikaanse tydskrif vir geneeskunde*. 1996;86(8):947-9.
7. Brugha R. Missed opportunities for immunizations at curative and preventive health care visits. *Transactions of the Royal Society of Tropical Medicine and Hygiene*. 1995;89(6):698.
8. Ibraheem R, Bello A, Adeboye M, Adeyeba D, Mohammed M. Missed vaccination opportunities at a secondary health facility in Ilorin, Nigeria. *Journal of Community Medicine and Primary Health Care*. 2016;28(1):31-7.
9. Madhi SA, Rees H. Special focus on challenges and opportunities for the development and use of vaccines in Africa. *Human vaccines & immunotherapeutics*. 2018;14(10):2335-9.
10. World Health Organization. Meeting of the Strategic Advisory Group of Experts on immunization, April 2016 - conclusions and recommendations. *Wkly Epidemiol Rec*. 2016;91(21):266-84.
11. World Health Organization. Planning guide to reduce missed opportunities for vaccination. Geneva: World Health Organization; 2017. Report No.: 9241512946.
12. World Health Organization. Progress Towards Global Immunization Goals - Summary presentation of key indicators Geneva, Switzerland: WHO and UNICEF; 2018 [cited 2019 8th January 2019]. Available from: https://www.who.int/immunization/monitoring_surveillance/SlidesGlobalImmunization.pptx?ua=1.
13. Lipsitz LA. Understanding health care as a complex system: the foundation for unintended consequences. *JAMA*. 2012;308(3):243-4.
14. World Health Organization. Immunization in practice: A practical guide for health staff. Geneva: World Health Organization; 2015.
15. Atun RA, Menabde N, Saluvere K, Jesse M, Habicht J. Introducing a complex health innovation—Primary health care reforms in Estonia (multimethods evaluation). *Health policy*. 2006;79(1):79-91.

16. Atun RA, Kyratsis I, Jelic G, Rados-Malicbegovic D, Gurol-Urganci I. Diffusion of complex health innovations—implementation of primary health care reforms in Bosnia and Herzegovina. *Health policy and planning*. 2007;22(1):28-39.
17. Bircher J, Hahn EG. Applying a complex adaptive system's understanding of health to primary care. *F1000Res*. 2016;5:1672.
18. Gray B. The Cynefin framework: applying an understanding of complexity to medicine. *J Prim Health Care*. 2017;9(4):258-61.
19. Atun R. Health systems, systems thinking and innovation. *Health Policy Plan*. 2012;27 Suppl 4(suppl_4):iv4-8.
20. Velandia-Gonzalez M, Trumbo SP, Diaz-Ortega JL, Bravo-Alcantara P, Danovaro-Holliday MC, Dietz V, et al. Lessons learned from the development of a new methodology to assess missed opportunities for vaccination in Latin America and the Caribbean. *BMC Int Health Hum Rights*. 2015;15(1):5.
21. Favin M, Steinglass R, Fields R, Banerjee K, Sawhney M. Why children are not vaccinated: a review of the grey literature. *International health*. 2012;4(4):229-38.
22. Rainey JJ, Watkins M, Ryman TK, Sandhu P, Bo A, Banerjee K. Reasons related to non-vaccination and under-vaccination of children in low and middle income countries: findings from a systematic review of the published literature, 1999-2009. *Vaccine*. 2011;29(46):8215-21.
23. Plsek P. Redesigning health care with insights from the science of complex adaptive systems. *Crossing the quality chasm: A new health system for the 21st century*. 2001:309-22.
24. Ellis BS, Herbert S. Complex adaptive systems (CAS): an overview of key elements, characteristics and application to management theory. *Journal of Innovation in Health Informatics*. 2010;19(1):33-7.
25. De Savigny D, Adam T. *Systems thinking for health systems strengthening*: World Health Organization; 2009.
26. Peters DH. The application of systems thinking in health: why use systems thinking? *Health Research Policy and Systems*. 2014;12(1):51.
27. Bala BK, Arshad FM, Noh KM. *Causal Loop Diagrams*. *System Dynamics*: Springer; 2017. p. 37-51.
28. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JP, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *PLoS medicine*. 2009;6(7):e1000100.
29. Freeman MK, Lauderdale SA, Kendrach MG, Woolley TW. Google Scholar versus PubMed in locating primary literature to answer drug-related questions. *Ann Pharmacother*. 2009;43(3):478-84.
30. Park J, Lee Y, Seo H, Jang B, Son H, Kim S, et al., editors. Risk of bias assessment tool for non-randomized studies (RoBANS): development and validation of a new instrument. 19th Cochrane Colloquium; 2011.
31. Sterne J, Higgins J, Reeves B. *A Cochrane Risk Of Bias Assessment Tool: for non-randomized studies of interventions (ACROBAT-NRSI)*, Version 1.0. 0, 24 September 2014. 2015.
32. Miller JJ. The inverse of the Freeman–Tukey double arcsine transformation. *The American Statistician*. 1978;32(4):138-.
33. World Health Organization. Expanded programme on immunization: missed immunization opportunities and acceptability of immunization *Weekly Epidemiological Record*. 1989;64:181 - 4.

34. DerSimonian R, Laird N. Meta-analysis in clinical trials. *Control Clin Trials*. 1986;7(3):177-88.
35. Clopper CJ, Pearson ES. The use of confidence or fiducial limits illustrated in the case of the binomial. *Biometrika*. 1934;26(4):404-13.
36. Nyaga VN, Arbyn M, Aerts M. Metaprop: a Stata command to perform meta-analysis of binomial data. *Arch Public Health*. 2014;72(1):39.
37. Higgins JP, Green S. *Cochrane handbook for systematic reviews of interventions*. version; 2005.
38. Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ*. 1997;315(7109):629-34.
39. Sterne JA, Gavaghan D, Egger M. Publication and related bias in meta-analysis: power of statistical tests and prevalence in the literature. *J Clin Epidemiol*. 2000;53(11):1119-29.
40. Peters JL, Sutton AJ, Jones DR, Abrams KR, Rushton L. Contour-enhanced meta-analysis funnel plots help distinguish publication bias from other causes of asymmetry. *J Clin Epidemiol*. 2008;61(10):991-6.
41. Burns J, Musa P, editors. *Validation of causal loop diagrams*. System Dynamics Society Conference, Atlanta, GA; 2001.
42. Eberlein RL, Peterson DW. Understanding models with Vensim™. *European Journal of Operational Research*. 1992;59(1):216-9.
43. Dawria A, Mohiedin A, Elshiek F, Tutu Z. Missed opportunities of immunization among children below 24 months visited Elmak Nimir Teaching Hospital, Sudan 2016. *International Journal of Research-GRANTHAALAYAH*. 2017;5(10):51-8.
44. Dyer JJ. Missed opportunities for immunisation in Natal health facilities. *South African medical journal = Suid-Afrikaanse tydskrif vir geneeskunde*. 1993;83(8):577-9.
45. Fermon F. [Lost immunization opportunities in Niamey, Niger]. *Developpement et sante : revue de perfectionnement medical et sanitaire en pays tropical*. 1995(115):24-7.
46. Himat S. Missed opportunities for immunization of children under two years of Age (0-23 months) Dongola province- Northern state -2003. Khartoum, Sudan: University of Khartoum; 2003.
47. Hipgrave D. Missed opportunities for immunisation at Kasungu. *Malawi Medical Journal*. 1992;8(2):76-7.
48. Josse R, Gbedonou P, Osseni R. Occasions manquées de vaccination: enquête en milieu urbain à Cotonou (Benin). *Médecine tropicale*. 1989;49(4):405-7.
49. Loevinsohn B. Missed opportunities for immunization during visits for curative care: practical reasons for their occurrence. *The American journal of tropical medicine and hygiene*. 1989;41(3):255-8.
50. Loevinsohn BP, Gareaballah E. Missed opportunities for immunization during visits for curative care: a randomized cross-over trial in Sudan. *Bull WHO*. 1992;70(3):335-9.
51. Malual AC, Jowi Y, Irimu G, Admani B. Missed opportunities for immunization among children attending a Paediatric Outpatient Clinic at Juba Teaching Hospital. *South Sudan Medical Journal*. 2018;11(2):36-9.
52. McCormick C, Biellik R, Shearley A, Saruchera H. Missed opportunities for vaccination in Chitungwiza, Zimbabwe 1995: a service deficiency which can easily be eliminated. *The Central African journal of medicine*. 1996;42(8):236-40.

53. Onyiriuka A. Vaccination default rates among children attending a static immunization clinic in Benin City, Nigeria. 2005.
54. Tagbo B, Onwuasigwe C. Missed immunization opportunitieess among children in Enugu. Nigerian Journal of Paediatrics. 2005;32(4):73-6.
55. Talani P, Nkounkou-Pika J, Mayanda H, Yala F. Les occasions de vaccination manquées à Brazzaville. Bull Soc Pathol Exot. 2000;93:121-22.
56. Ubajaka F, Ukegbu A, Okafor N, Ejiofor O. The prevalence of missed oppor-tunities for immunization among children utilizing immunization services in NNAMDI AZIKIWE University Teaching Hospital, NNEWI. J Biol Agric Healthc. 2012;6(2).
57. World Health Organization. Expanded Programme on Immunization. Missed opportunities for immunization - Egypt. Weekly Epidemiological Record 1989;64:93 - 4.
58. World Health Organization. Expanded Programme on Immunization. Missed opportunities for immunization - Ethiopia. Weekly Epidemiological Record. 1990;65:167 - 70.
59. World Health Organization. The global vaccine action plan 2011–2020. Geneva, Switzerland2012.
60. WHO Regional Office for Africa. Regional Strategic Plan for Immunization 2014 - 2020. Brazzaville, Republic of Congo: WHO; 2015.
61. World Health Organization. 2017 Assessment Report of the Global Vaccine Action Plan Strategic Advisory Group of Experts on Immunization. Licence: CC BY-NC-SA 3.0 IGO. Geneva, Switzerland: World Health Organization; 2017.
62. Brown P, Brunnhuber K, Chalkidou K, Chalmers I, Clarke M, Fenton M, et al. How to formulate research recommendations. Bmj. 2006;333(7572):804-6.

Supplementary material 2.1

Supplementary Table 2.1: PUBMED search strategy modified for other databases

1	Missed[tiab] AND opportunit*[tiab]
2	Immunization[mh] OR immuni*[tiab] OR vaccin*[tiab] OR revaccin*[tiab] OR innoculat*[tiab] OR inoculat*[tiab]
3	Africa[MeSH] OR Africa*[tiab] OR Algeria*[tiab] OR Angola*[tiab] OR Benin[tiab] OR Botswana[tiab] OR Motswana[tiab] or Batswana[tiab] OR Burkina Faso[tiab] OR Burkinabé[tiab] OR Burundi[tiab] OR Cameroon*[tiab] OR Canary Islands[tiab] OR Cape Verd*[tiab] OR Central African Republic[tiab] OR Chad[tiab] OR Comoros[tiab] OR Comorian*[tiab] OR Congo*[tiab] OR Democratic Republic of Congo[tiab] OR Djibouti[tiab] OR Egypt*[tiab] OR Equatorial Guinea[tiab] OR Eritrea[tiab] OR Ethiopia*[tiab] OR Gabon*[tiab] OR Gambia[tiab] OR Ghana[tiab] OR Guinea[tiab] OR Guinea Bissau*[tiab] OR Ivory Coast[tiab] OR Cote d'Ivoire[tiab] OR Ivorian[tiab] OR Jamahiriya[tiab] OR Kenya[tiab] OR Lesotho[tiab] OR Mosotho[tiab] or Basotho[tiab] OR Liberia[tiab] OR Libya*[tiab] OR Libia[tiab] OR Madagascar[tiab] OR Malawi[tiab] OR Mali[tiab] OR Mauritania*[tiab] OR Mauritius[tiab] OR Morocc*[tiab] OR Mozambique[tiab] OR Mocambique[tiab] OR Mozambican[tiab] OR Namibia[tiab] OR Niger*[tiab] OR Nigeria*[tiab] OR Principe[tiab] OR Reunion[tiab] OR Rwanda*[tiab] OR Sao Tome[tiab] OR Senegal*[tiab] OR Seychell*[tiab] OR Sierra Leone*[tiab] OR Somali*[tiab] OR South Africa*[tiab] OR St Helena[tiab] OR Sudan*[tiab] OR Swazi[tiab] OR Swaziland[tiab] OR Tanzania*[tiab] OR Togo[tiab] OR Tunisia*[tiab] OR Uganda*[tiab] OR Western Sahara[tiab] OR Zaire[tiab] OR Zambia*[tiab] OR Zimbabwe*[tiab]) NOT (guinea pig[tiab] OR guinea pigs[tiab] OR aspergillus niger[tiab])

Chapter 3: Application of quality improvement approaches in healthcare settings to reduce missed opportunities for childhood vaccination: a scoping review

3.0 About this chapter

In this chapter, we report a scoping review of quality improvement projects conducted in health facilities to address missed opportunities for vaccination in children. This chapter has been published by Taylor and Francis Group in *Human Vaccines and Immunotherapeutics* on 22nd April 2019, and can be accessed through the following link:

<https://doi.org/10.1080/21645515.2019.1600988> The full citation is as follows: Abdu A.

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Wiysonge. Application of quality improvement approaches in health-care settings to reduce missed opportunities for childhood vaccination: a scoping review. *Human Vaccines & Immunotherapeutics* 2019; 15(10):1-10. DOI: [10.1080/21645515.2019.1600988](https://doi.org/10.1080/21645515.2019.1600988). Epub 2019 Apr 22.

3.1 Abstract

Background: Missed opportunities for vaccination (MOV) is a poor reflection of the quality of care for children attending health facilities. It also contributes to a reduction in overall immunization coverage. Although there is a growing interest in the use of quality improvement (QI) in complex health systems to improve health outcomes, the degree to which this approach has been used to address MOV is poorly understood.

Methods: We conducted a scoping review using Arksey and O'Malley's framework to investigate the extent to which quality improvement has been used in health facilities to reduce missed opportunities for vaccination. The review followed five stages as follows: (1) identifying the research question, (2) identifying the relevant studies, (3) selecting the studies,

(4) charting data, and (5) collating, summarizing and reporting results. The search strategy included electronic databases and grey literature.

Results: We identified 12 pieces of literature on quality improvement projects focused on addressing missed opportunities for vaccination. 11 were published manuscripts, and one was a conference presentation. All the QI projects published were conducted in the United States and majority were between 2014 - 2018. A total of 45 change ideas targeting providers, clients, and health system were identified.

Conclusion: This study generated important evidence on the use of QI in health facilities to reduce MOV. In addition, the result suggests that there is a growing interest in the use of this approach to address MOV in recent years. However, no literature was found in low and middle-income countries especially sub-Saharan Africa.

3.2 Introduction

Immunization is one of the most effective and cost-effective public health interventions for preventing morbidity and mortality from common childhood infectious diseases (1-3). In addition to averting deaths, immunization also improves long-term productivity and has positive ecological externalities (4). As a result childhood immunization is considered a priority child health service in health facilities (5). Despite this, many children who are eligible for vaccination often make contact with health services and are still missed by the immunization sub-system thus resulting in missed opportunities for vaccination (MOV) (6). This MOV can occur during health care visits for curative or preventive services (6, 7). Its prevalence in low-and-middle-income (LMIC) countries is estimated to be 32.2% (6). A recent review on MOV among African children from 14 countries found a pooled prevalence of 27.26% (8). In the same study, the complexity of MOV was highlighted (8). Using complex adaptive systems lens, it was shown that interrelated and interdependent factors which originates from multiple stakeholders including caregivers, health workers as well as health systems managers were responsible for MOV (8). According to the World Health Organization, MOV contributes to a further reduction in childhood immunization coverage level at district and national level (9). Its impact on this important public health indicator has reinvigorate WHO's interest in address it across health systems (9).

Quality improvement (QI), which originated from industrial manufacturing has emerged as one of the main approaches for improving health outcomes within complex health systems (10-13). This is because quality improvement methodologies enable the use of multicomponent interventions concurrently to institute change at multiple levels and allows experiential learning (12, 14, 15). Within the context of immunization programmes, QI would differ from general implementation activities designed to improve uptake of immunization. This is because QI process would involve specific activities like baseline data collection, testing iterative cycles of intervention packages to improve immunization uptake, brainstorming on progress, and periodic reflections on the change packages supported by continuous data collection on the outcome of interest which can then be used to inform modifications. Several quality improvement models exist, however, the most commonly used are Model for Improvement (MFI), lean, and six-sigma (16-20). Model for improvement is a hybrid of two frameworks; Total Quality Management (TQM) and Rapid Cycle Improvement (RCI) (21). It uses Plan-Do-Study-Act (PDSA) cycles to test change ideas (21). Lean and six

sigma are somewhat similar, however lean is concerned with reducing wastage, while six sigma focuses on reducing process variation (22). Lean six sigma is an integration of the two models which focuses on defect prevention and is usually used when wastage and process variation coexist (23).

At core, quality improvement entails process change with resultant variation in outcomes (10, 11). It has been used in health facilities in high-income countries to improve neonatal and child health outcomes (24-26). Similarly, there is also evidence of its use to strengthen health systems in low- and middle-income countries (27). Studies conducted in Rwanda, Ghana, and Nigeria have demonstrated the impact of quality improvement on maternal health outcomes (28-30). However, there is scarcity of information on how quality improvement has been applied within the immunization system to reduce MOV.

Therefore, in this study, we explored the extent to which QI has been used to address MOV using a scoping review methodology (31). We adopted Arksey and O'Malley's framework for conducting scoping review (31). The review followed five stages as follows: (1) identifying the research question, (2) identifying the relevant studies, (3) selecting the studies, (4) charting data, and (5) collating, summarizing and reporting results (31). For this study, we defined a scoping review as a research synthesis technique for mapping literature on a particular field of study or topic to identify key concepts and gaps so as to inform further research, as well as policy and practice (32).

We chose to use a scoping review method as we intend to explore the degree to which QI has been applied in healthcare setting to reduce MOV, rather than sum up available evidence on the effect of QI on MOV (33). This review methodology is as transparent as a systematic review as it employs rigorous approaches to identify literature that are relevant to a research question (33). It is suitable for broad questions that would likely combine diverse literature (33). Using a scoping review will enable us to identify different types of change ideas for reducing MOV that have been used to broadly target stakeholders such as caregivers, health workers and health systems (33). Our study filled an existing knowledge gap by presenting a broad descriptive overview of the application of QI in healthcare settings to reduce MOV. This study is relevant for researchers as it highlighted the nature and characteristics of available literature on the topic. It is also relevant for health practitioners and policy makers that are planning to use the quality improvement approach within their setting to address this

problem. This scoping review was conducted before embarking on a quality improvement project in primary healthcare facilities in a resource constrained setting.

The objectives of this study were as follows:

- a) To map and describe existing literature on quality improvement projects to reduce missed opportunities for vaccination within the context of routine childhood immunization.
- b) To identify the quality improvement models, change ideas, and study designs used in quality improvement projects to reduce missed opportunities for vaccination within the context of routine childhood immunization.

3.3 Methodology

A review team was established comprising of the principal investigator and three supervisors with expertise in research synthesis, epidemiology and vaccinology (34). The team deliberated upon and agreed on the broad research question to be addressed as well as the review protocol.

3.3.1 Stage 1: Identify the research question

The scoping review question was, “What is the nature and extent of use of quality improvement approaches in health facilities to reduce missed opportunities for vaccination within the context of routine childhood immunization?” Due to the broad nature of this review question, with its main focus on mapping existing literature, a systematic review was not deemed to be appropriate (35). Since emerging consensus on knowledge synthesis methodologies have made clearer the applicability of a broad range of other methods, we used this to inform our choice of scoping review methodology to answer this question (36, 37).

Since routine childhood immunization for children extend to those in the adolescent age group, they were included as part of the population of interest (38). The detailed Population Intervention Comparator and Outcome (PICO) elements for the review question is shown in **Box 3.1**.

Box 3.1: PICO Elements for scoping review question

Population	Children and adolescents
Intervention	Quality improvement
Comparator	Usual practice
Outcome	Proportion, frequency or percentage of missed opportunities for vaccination
Study setting	Health facilities

For this study, we adopted the Cochrane Effectiveness Practice and Organization of Care (EPOC) group's definition of quality improvement (QI) as “an iterative process to review and improve care that includes the involvement of healthcare teams, analysis of a process or system, a structured process improvement method or problem-solving approach, and use of data analysis to assess change” (39). Since our interest is in routine childhood immunization, the following antigens were considered: Bacillus Calmette-Guerin (BCG), hepatitis B, Polio, Diphtheria-Tetanus-Pertussis containing vaccine, *Haemophilus influenzae type b*, pneumococcal (conjugate), rotavirus, measles, rubella and human papilloma virus (38). Other antigens such as: yellow fever, Japanese encephalitis, tick-borne encephalitis, typhoid, cholera, meningococcal, hepatitis A, rabies, dengue, mumps, seasonal influenza, and varicella, that are indicated for children under certain conditions like place of residence, type of population, and immunization programme were also considered (38).

3.3.2 Stage 2: Identifying relevant studies

To identify literature (published and unpublished) appropriate for answering the research question, we employed a search strategy involving:

1. Three (3) electronic databases and manual search of reference lists of relevant studies
2. Google search
3. Contacting networks and organizations involved in quality improvement

Electronic databases

Three (3) electronic databases: PubMed, Scopus, and Web of Science were searched on 4th July 2018 on the internet. These databases were selected to ensure a comprehensive inclusion of all published literature. To ensure that all possible publications were found, date, language,

or document type restrictions were not specified during database search. Using the research question, we developed the following search terms: “quality improvement”, “implementation strategy” “implementation process”, “Plan do study act”, “define measure analyze improve control”, “define measure analyse improve control”, “define measure analyse design verify”, “define measure analyze design verify”, “lean six sigma”, “immunization”, “missed opportunities”, “infant”, “childhood”, “teenager” and “adolescent” among others. These search terms are keywords that combines quality improvement with missed opportunities for vaccination in children and adolescent. The search terms were tailored to each database. Detailed search strategy developed with input from an information specialist is attached as **Supplementary Material 3.1**. All citations exported from databases were imported to Endnote X7.7.1. While on the reference manager, duplicate of citations were removed. The reference list of the selected manuscripts was also manually searched to identify any relevant paper that reported the use of quality improvement approach to address missed opportunities for vaccination.

Grey literature

Advanced Google search using the following url: https://www.google.com/advanced_search was implemented to identify grey literature that are relevant to the review question (40). The keywords that were used for electronic database search were also applied. The search filters were left at their default setting so as to include results in any language, from any geographical region, and without data limits among others. Since Google search has the tendency to produce a high search volume, we limited our search to the first fifty (50) results (41).

Networks and organizations

Experts at the American Academy of Pediatrics were contacted by email with a request for any published or unpublished report on the use of quality improvement approaches to address missed opportunities for vaccination among children. The use of quality improvement practices is part of the academy’s mission of ensuring high standards of health for children (42).

3.3.3 Stage 3: Study selection

A set of eligibility criteria with inclusion and exclusion criteria were developed while preparing the protocol to help in removing studies that did not answer the review question. It was agreed that these eligibility criteria can be modified post-hoc as the authors become more familiar with the studies.

Inclusion criteria were as follows:

- a. All literature reporting a quality improvement approach aimed at reducing missed opportunities for vaccination for children and adolescents.
- b. Vaccines that are used for routine immunization
- c. QI approaches implemented in a health facility setting

Exclusion criteria were as follows:

- a. Quality improvement aimed at improving immunization rate in high-risk children with deficient immune system
- b. QI approaches implemented within a community setting

After identifying relevant literature, two authors independently screened the titles and abstracts of all publications obtained from the electronic databases. If the studies described the use of quality improvement in a health facility setting to reduce missed opportunities for vaccination, its full text was retrieved. There was no masking of reviewers involved in the screening to author name or journal. It was agreed *apriori* that the full text of publications without abstracts will automatically be considered. The prespecified inclusion and exclusion criteria were applied to the full text of the publications to identify the “best fit”. The assistance of librarians at the medicine and health sciences library of Stellenbosch University, South Africa, was sought to help retrieve articles that were published in journals that the university did not subscribe to. It was also agreed that if full text could not be retrieved, then abstract could be used. During the study selection, the two reviewers resolved any disagreements through discussion. **Figure 3.1** is a four-phased flow diagram from identification through inclusion (43). The Google search results were also screened by the two authors.

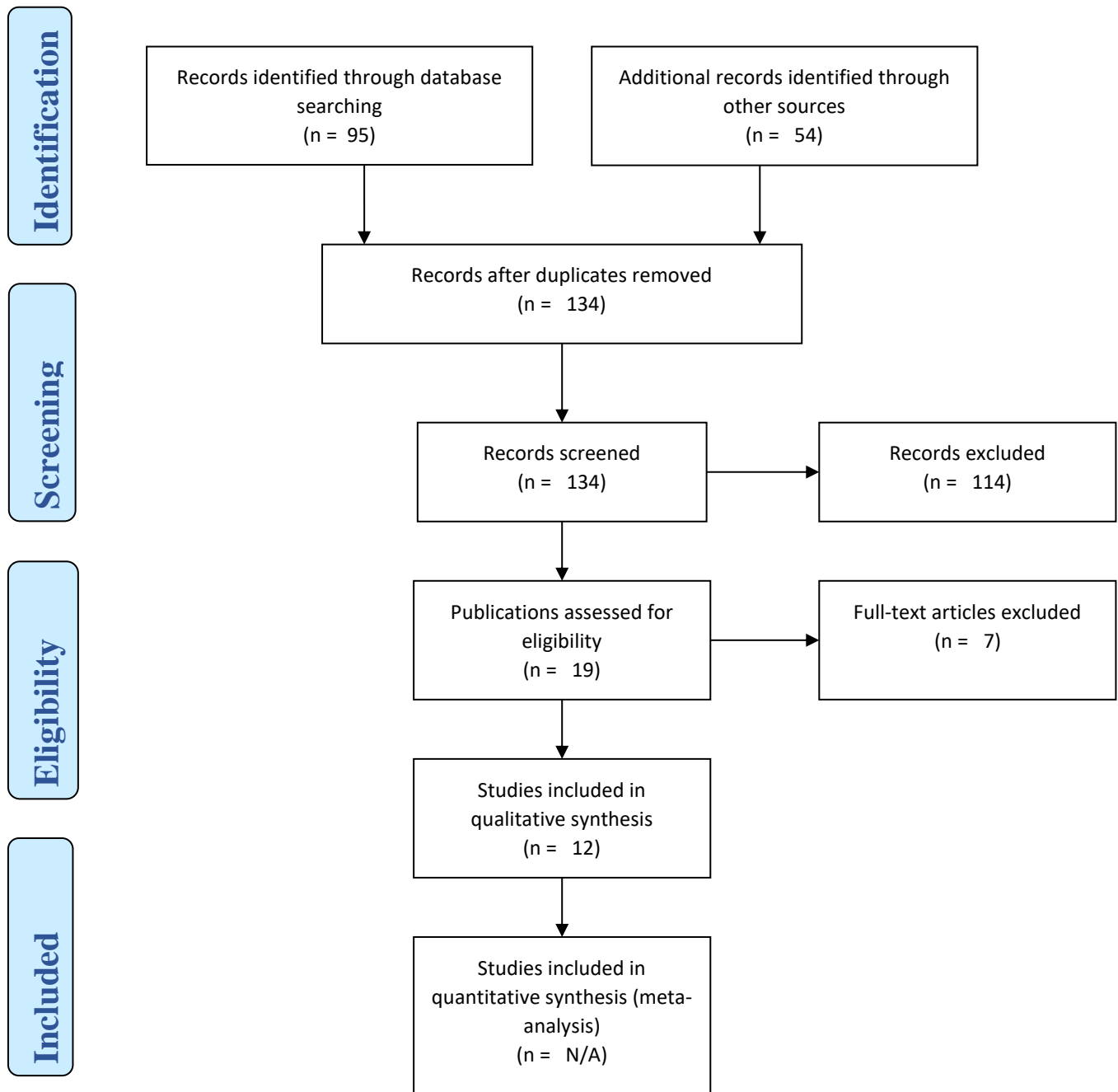


Figure 3.1: Adapted PRISMA flow chart

3.3.4 Stage 4: Charting the data

Two authors independently charted key information from the included publications. An Excel spreadsheet was used for this purpose. The charting approach used was similar to that of a narrative review as we obtained information about the QI projects (44). The recorded information is presented on **Table 3.1**.

Table 3.1: Key information charted and their description

Information	Description
<i>General characteristics</i>	
ID	Identifier of the publication
year of publication	Year of publication of the document
Country	Location of institution of the first author
type of publication	Type of document
Language	Language of publication
<i>Setting and target population</i>	
Level of healthcare	Category of health facility where the quality improvement project was implemented
Context	Setting in which the quality improvement project was conducted
Target population	Individuals whom the quality improvement was meant to have an impact on
Age group of target population	Age category of the individuals targeted in the quality improvement project
<i>Quality improvement process</i>	
Quality Improvement (QI) strategy	The strategies that were used during the quality improvement project
Quality Improvement (QI) team	people responsible for implementing the quality improvement project
Quality Improvement (QI) model	theoretical framework or model of the quality improvement project
Quality Improvement (QI) method	process of iterative implementation of the quality improvement activities
Vaccines	antigens that were targeted

3.3.5 Stage 5: Collating, summarizing and reporting the results

Charted information was collated using Microsoft Excel 2016®. Same software was used for coding the data. Analysis was done using Microsoft Excel® as well. Number of published literatures over the study periods were calculated. Descriptive statistics (frequency and percentage) of country affiliation, language of publication, publication type, and institutional affiliation of authors was also calculated. Vaccines targeted in each quality improvement interventions were presented.

3.4 Results

A total of 12 publications met the eligibility criteria for this review. The total number of publications that were assessed for eligibility were 19, and 7 were excluded as already shown in **Figure 3.1**. In two of the excluded studies, the focus was on general pediatric care (45, 46). Others focused on immunization coverage (47-51). The electronic databases search yielded nine publications. Manual search of the reference list of eligible publication yielded an additional two publications. While the grey literature search yielded one conference presentation. No publication was obtained from the organizations that were contacted.

3.4.1 Description of the characteristics of included publications

The country affiliation of all the first authors included in this review was the United States of America (USA). Their type of institutional affiliation varies with 50% affiliated with a university. Majority of included literature were published in the last five years (2014 – 2018). Other bibliometric characteristics of the publications are shown on **Table 3.2**.

Table 3.2: General features of publications on use of quality improvement to address missed opportunities for childhood vaccination

Characteristics	Frequency	Percentage
Year of publication		
1999 - 2003	2	16.67
2004 - 2008	1	8.33
2009 - 2013	0	
2014 - 2018	9	75.00
Country affiliation		
United States of America	12	100
Others	0	
Publication type		
Published literature	11	91.67
Conference proceedings	1	8.33
Type of institutional affiliation of first author		
University	5	41.67
Hospital	4	33.33
Government agency	3	25.00

3.4.2 Quality improvement interventions

Most of the quality improvement projects that were conducted covered routine childhood immunization, while four focused solely on human papillomavirus virus (HPV) vaccine. In one of the projects, the age group of the target population for HPV vaccine extended till 26 years. This extension to 26 years of age is a function of United States recommendations for catch-up immunization for women who did not receive HPV vaccine as adolescents. In one of the projects, a QI intervention was instituted in a primary care clinic in Denver to reduce MOV among children up to 25 months of age (52). This clinic is in an inner-city teaching hospital that serves low income families (52). Three difference change ideas; chart prompts, provider education and provider reminders were implemented (52). The change ideas targeted nurses and clinicians (52). Details of each article with the vaccines and target population are presented on **Table 3.3**.

Table 3.3: Target population and vaccine(s) targeted in quality improvement practices to address missed opportunities for vaccination

Authors	Study title	Target population	Vaccine(s)
Published literature			
Daley, M. F., et al.	Quality improvement in immunization delivery following an unsuccessful immunization recall(52)	children aged 3 - 35 months	All routine immunization
Daly, K. L., et al.	A University Health Initiative to Increase Human Papillomavirus Vaccination Rates(53)	Young adults aged 18 - 26 years	Human papillomavirus (HPV) vaccine
Fiks, A. G., et al.	Improving HPV Vaccination Rates Using Maintenance-of-Certification Requirements(54)	Adolescents aged 11 - 17 years	Human papillomavirus (HPV) vaccine
Jones, K. B., et al.	Improving Immunizations in Children: A Clinical Break-even Analysis(55)	children aged three years and below	All routine immunization
Krantz, L., et al.	Increasing HPV Vaccination Coverage Through Provider-Based Interventions(56)	Adolescents aged 13 - 17 years	Human papillomavirus (HPV) vaccine Tetanus-diphtheria-pertussis vaccine (Tdap), Quadrivalent meningococcal vaccine (Men-ACWY), and Human papillomavirus (HPV) vaccine
Moore, K. L., et al.	Tennessee's 3-Star Report: Using Available Data Systems to Reduce Missed Opportunities to Vaccinate Preteens(57)	Adolescents aged 11 - 13 years	Human papillomavirus (HPV) vaccine
Rand, C. M., et al.	A Learning Collaborative Model to Improve Human Papillomavirus Vaccination Rates in Primary Care(58)	Adolescents aged 11 - 17 years	Human papillomavirus (HPV) vaccine
Jones, K. B., et al.	Improving pediatric immunization rates: description of a resident-led clinical continuous quality improvement project(59)	children aged three years and below	All routine immunization
Sinn, J. S., et al.	Improving immunization rates in private pediatric practices through physician leadership(60)	children aged 9 to 30 months	All routine immunization
Melinkovich, P., et al.	Improving pediatric immunization rates in a safety-net delivery system(61)	children aged three years and below	All routine immunization
Carlin, E., et al.	Using Continuous Quality Improvement Tools to Improve Pediatric Immunization Rates(62)	children aged two years and below	All routine immunization

Authors	Study title	Target population	Vaccine(s)
Conference presentation			
Gurov, Heidi	Assessment-Feedback-Incentive-Exchange (AFIX) Overview(63)	Children below 35 months of age, and adolescents aged 13 - 17 years	All routine immunization

Although all the quality improvement projects were implemented within a health facility the level of healthcare varied across studies (52-62). The context within which these quality improvement projects were implemented also varied from one another (52-62). One of the quality improvement practices was implemented within a health center in an urban public university (53). In another study, the quality improvement practice was implemented in a clinic that serves mainly low-income families (52).

In all the quality improvement projects conducted, quality improvement teams implemented multiple change ideas (interventions) targeting various levels of stakeholders (52-62). The change ideas were about evenly divided between provider- and patient-focused strategies with few cross-cutting strategies. On **Table 3.4**, all the compiled change ideas are classified according to their level of influence.

Table 3.4: Classification of quality improvement interventions (change ideas) used in quality improvement projects to address missed opportunities for vaccination

Interventions for providers	Interventions for clients	Cross-cutting interventions
Place registry-generated copy of child's immunization data on front of chart at every visit (52)	Providing a strong recommendation for vaccination at every visit (53)	Improve record keeping by keeping immunization history current (60)
Make notation on clinician encounter form whenever child is due to visit (52)	Using patient reminder systems (53)	record keeping (62)
Educate providers regarding methods for reducing missed opportunities (52)	Implementing campus-based marketing strategies (53)	Developing an immunization registry to track patients (61)
Place reminder posters prominently in clinic (52)	Use of consistent language to recommend HPV vaccine (54)	

Interventions for providers	Interventions for clients	Cross-cutting interventions
Prevent missed opportunities to vaccinate by increasing provider acknowledgement of vaccine history (53)	Provider emphasizing the vaccine as a tool for cancer prevention (54)	
Distributing immunization records for all scheduled pediatric patients to provider medical assistants teamlets (55)	Provider emphasizing the vaccines at acute visits (54)	
educational seminar on HPV for physicians, residents, nurses, and medical assistants(56)	Mailing letters to caregivers of children under 3 years of age providing information on reasons for immunization and encourage them to make appointment to obtain missing immunizations (55)	
weekly individualized audit to providers who missed an opportunity to vaccinate a patient against HPV (56)	Administering all recommended vaccines at the same visit (57)	
Allowing staffs to schedule their HPV visits (56)	Making strong recommendations for vaccines (57)	
Support staffs indicating to providers when client is HPV vaccine eligible (56)	Discussing the need for immunizations with caregivers at that day's visit (59)	
"Best practice alert" for HPV in EMR (56)	Use all clinical encounter to screening at every visit (60)	
Electronic reminders using Huddle (56)	Administer immunization at some sick visits (60)	
Auditing and feedback (57)	Administer immunization at any opportunity (60)	
Providers were trained on offering a strong recommendation for HPV vaccination (58)	Using only true contraindication to immunization (60)	

Interventions for providers	Interventions for clients	Cross-cutting interventions
Practices implemented provider prompts and/or standing orders and/or reminder/recall if desired (58)	Simultaneous administration of multiple vaccines (60)	
Provide monthly feedback on missed opportunities for vaccination to assess their progress (58)	Administering DTP at 12 or 15 months instead of 18 months (60)	
Teach residents about the principles of FOCUS-PDSA through didactic lecture (59)	Recommendations pertained to missed opportunities (62)	
Printing daily report with the immunization record for that day's pediatric patients (59)	Encourage parents to bring immunization record to all clinic visits (60)	
Algorithms for catch-up of patients not on schedule or with incomplete immunizations (62)	Educating parents even when refusal occur (63)	
Conducting regular assessment of immunization levels with provision of clinic-specific feedback (61)		
Holding team-based quality improvement meetings (61)		
Use of standing orders on immunization in clinics (63)		
Training of health care providers (63)		

*HPV = Human papilloma virus, *EMR = Electronic Medical Record, *FOCUS-PDSA = Find Organize Clarify Understand Select – Plan
Do Study Act

3.4.3 Quality improvement models, methods and study designs

In three of the reviewed publications, continuous quality improvement (CQI) model was used (55, 59, 60). Only one publication reported the use of collaborative quality improvement model (58). The use of Plan-Do-Study-Act (PDSA) as the method for quality improvement

was reported in four studies (54, 55, 58, 59). In all the publications quality improvement practice was implemented by quality improvement teams (52-62). In the quality improvement projects identified, quasi experimental designs like pre-post design, before and after studies, and time series designs were used to evaluate the effect of the interventions (52, 55-60).

3.5 Discussion

3.5.1 Summary of results

We embarked on this scoping review to explore the extent to which quality improvement has been used to address missed opportunities for vaccination within the context of routine childhood immunization. Our objective was to map and describe existing literature, and identify the quality improvement models, change ideas, and study designs used in quality improvement projects. Our search for published and grey literature yield 12 publications (11 published literature, and 1 conference presentation). Based on the charted information from these publications, we found that all the quality improvement projects were implemented in the United States and majority of them were conducted between 2014 and 2018. In the quality improvement projects implemented, multicomponent change ideas were used. We identified 45 change ideas across all the projects and classified them into three namely; interventions for providers, interventions for clients, and cross-cutting interventions. It was beyond the ambit of this scoping review to conduct an evaluation of the methodological quality of individual studies included.

3.5.2 Strengths and limitations of the study

A key strength of this review is that we employed a rigorous and transparent search strategy to identify existing literature on the use of quality improvement to address missed opportunities for vaccination. In addition, we did not restrict our search to any language, date of publication or document type. Some limitations of this review should also be considered. Despite the comprehensiveness of our search strategy, we cannot conclude that we found all the publications due to the broad nature of quality improvement as a field of practice. It is still possible that we missed some papers. We were also unable to obtain publications and reports from organizations engaged in quality improvement projects for immunization, as

such, it's possible that other non-public literature exist that have not been included in this review.

3.5.3 Quality improvement and missed opportunities for vaccination

Our study confirms the emerging interest in quality improvement as majority of identified literature were published between 2014 - 2018. As practitioners increasingly understand and begin to view MOV from the complexity lens, a further rise in the use of quality improvement to address it might occur. However, the overall volume of quality improvement projects to address missed opportunities for vaccination, which is a healthcare quality issue with substantial population health implications, was low. Furthermore, all the identified publications were for projects conducted in the United States. Although global organizations such as the World Health Organization recognizes the role of QI in health systems, its use in immunization systems in low- and middle-income countries to reduce missed opportunities for vaccination seems low (64). Many factors including paucity of skills to conduct and report QI interventions or failure to publish QI projects might be contributing to this.

Authors of the publications included in this review reported the use of multiple change ideas which is consistent with the science of improvement (10). While some of these change ideas are targeted at providers, others focus on clients and the system, thus enabling a multipronged approach. However, the process of selection of these change ideas were rarely described enough to enable replication in other settings. In a resident-led clinical QI project to improve immunization rate, third year residents engaged immunization stakeholders to implement a set of activities (59). These activities include printing daily immunization reports, distributing them to health care providers and discussion about immunization with parents and guardians (59). However, it is unclear how the residents arrived at these choice of change ideas (59).

Most of the quality improvement projects reviewed reported only the quality improvement outcome measure and this practice is inconsistent with current guidance on quality improvement in healthcare (65). It is essential to include and report on process and balancing measures as well (65). Process measures will enable QI practitioners to track whether the system is performing as planned (65). While balancing measures will allow tracking of the influence of the quality improvement project on other parts of the system (65). Balancing measures are particularly important as it will provide information on whether the change ideas causing improvement in one unit, is decreasing a desirable outcome in others. In

addition to these measures, more recent improvement models have also included implementation outcomes (66).

Due to the “real world” context within which quality improvement are implemented, quasi experimental designs are sometimes more feasible (67). As expected, most of the publications reported the use of these study designs. However, it is important to consider additional design features to these quasi-experimental designs or conduct pragmatic or hybrid trials to improve confidence in the effect measure attributed to quality improvement interventions (68-71).

3.5.4 Implications for future research

In view of our findings, we recommend more research. Our research recommendations, which follows the EPICOT+ format are presented in **Box 3.2** (72).

Box 3.2: Use of EPICOT+ to highlight research recommendations based on gaps identified in a scoping review on the use of quality improvement to address missed opportunities for vaccination

Element	Recommendation(s)
Evidence (State of evidence)	<p>Core elements</p> <p>Existing quality improvement projects for addressing missed opportunities for vaccination among children were conducted in the United States.</p>
Population (Population of interest)	<p>Quality improvement projects addressing missed opportunities for vaccination targeting;</p> <ul style="list-style-type: none"> - Children in low- and middle-income countries especially in sub-Saharan Africa - HIV exposed infants - Children in internally displaced persons camps - Children in hard to reach areas - Children in urban areas (slums and non-slums) - Adolescents including those in LMICs
Interventions	<ul style="list-style-type: none"> - Quality improvement projects with multiple change ideas targeted at different stakeholders that are systematically selected from evidence-based innovations or generated de-novo by healthcare workers in quality improvement teams. - Collaborative quality improvement projects.
Comparisons	Control (non-intervention) health facilities

Outcomes	<ul style="list-style-type: none"> - Proportion of missed opportunities for vaccination disaggregated by vaccines and vaccine doses. - Process outcomes to measure how the quality improvement interventions were delivered - Balancing outcome to assess the effect of quality improvement on other program areas - Implementation outcomes such as acceptability, adoption, appropriateness, fidelity, feasibility, cost, penetration and sustainability
Time stamp	July 2018
Study type	Optional element Quasi experimental design (Interrupted time series design with non-equivalent control groups), pragmatic trials and implementation-effectiveness hybrid trials.

We recommend the use of standardized guidance such as Standards for QUality Improvement Reporting Excellence - SQUIRE 2.0 to report future studies (73). This would greatly enhance the sharing of best practices. Also, researcher and practitioners can place related grey literature on repositories that are accessible to wide range of audience.

3.6 Conclusion

This scoping review identified and described the extent of current publications on use of quality improvement approach to address MOV. There is a growing interest in the use of quality improvement to improve health outcomes, and this was also observed for MOV. Given that only few publications were found, all of which were conducted in the United States, buttresses the need for this systematic appraisal of currently available literature. No published or grey literature was found in low and middle-income countries especially sub-Saharan Africa.

3.7 Competing interest

None declared

3.8 Author contribution

AAA conceptualized the study, drafted the review protocol, conducted the literature search, screened publications and charted data, conducted the data analysis and interpretation, and wrote the first and subsequent drafts of the manuscript. CSW, OAU, MAG reviewed and approved the protocol, contributed to data analysis and interpretation, manuscript development and approved the final manuscript. EOW screened publications and charted data and contributed to manuscript development.

3.9 References

1. Akmatov MK, Kretzschmar M, Kramer A, Mikolajczyk RT. Timeliness of vaccination and its effects on fraction of vaccinated population. *Vaccine*. 2008;26(31):3805-11.
2. Stack ML, Ozawa S, Bishai DM, Mirelman A, Tam Y, Niessen L, et al. Estimated economic benefits during the 'decade of vaccines' include treatment savings, gains in labor productivity. *Health affairs*. 2011;30(6):1021-8.
3. Akmatov MK, Mikolajczyk RT. Timeliness of childhood vaccinations in 31 low and middle-income countries. *J Epidemiol Community Health*. 2012;66(7):e14.
4. Deogaonkar R, Hutubessy R, van der Putten I, Evers S, Jit M. Systematic review of studies evaluating the broader economic impact of vaccination in low and middle income countries. *BMC public health*. 2012;12(1):878.
5. World Health Organization. Standards for improving the quality of care for children and young adolescents in health facilities. Geneva, Switzerland 2018.
6. Sridhar S, Maleq N, Guillermet E, Colombini A, Gessner BD. A systematic literature review of missed opportunities for immunization in low- and middle-income countries. *Vaccine*. 2014;32(51):6870-9.
7. Hutchins SS, Jansen HA, Robertson SE, Evans P, Kim-Farley RJ. Studies of missed opportunities for immunization in developing and industrialized countries. *Bull WHO*. 1993;71(5):549-60.
8. Adamu AA, Sarki AM, Uthman OA, Wiyeh AB, Gadanya MA, Wiysonge CS. Prevalence and dynamics of missed opportunities for vaccination among children in Africa: Applying systems thinking in a systematic review and meta-analysis of observational studies. *Expert Rev Vaccines*. 2019.
9. World Health Organization. Planning guide to reduce missed opportunities for vaccination. Geneva, Switzerland: World Health Organization; 2017.
10. Shojania KG, Grimshaw JM. Evidence-based quality improvement: the state of the science. *Health affairs*. 2005;24(1):138-50.
11. Batalden PB, Davidoff F. What is "quality improvement" and how can it transform healthcare? : BMJ Publishing Group Ltd; 2007.
12. Leviton L. Reconciling complexity and classification in quality improvement research. *BMJ quality & safety*. 2011;20(Suppl 1):i28-i9.
13. James BC, Savitz LA. How Intermountain trimmed health care costs through robust quality improvement efforts. *Health Affairs*. 2011;30(6):1185-91.
14. Kraft S, Carayon P, Weiss J, Pandhi N. A simple framework for complex system improvement. *American journal of medical quality : the official journal of the American College of Medical Quality*. 2015;30(3):223-31.
15. Dixon-Woods M, McNicol S, Martin G. Ten challenges in improving quality in healthcare: lessons from the Health Foundation's programme evaluations and relevant literature. *BMJ Qual Saf*. 2012;bmjqs-2011-000760.
16. Batalden PB, Stoltz PK. A framework for the continual improvement of health care: building and applying professional and improvement knowledge to test changes in daily work. *The Joint Commission journal on quality improvement*. 1993;19(10):424-47.
17. Burgess N, Radnor Z. Evaluating Lean in healthcare. *International journal of health care quality assurance*. 2013;26(3):220-35.
18. Radnor ZJ, Holweg M, Waring J. Lean in healthcare: the unfilled promise? *Social science & medicine*. 2012;74(3):364-71.

19. Powell A, Rushmer R, Davies H. A systematic narrative review of quality improvement models in health care: NHS Quality Improvement Scotland; 2009.
20. Corn JB. Six sigma in health care. *Radiologic technology*. 2009;81(1):92-5.
21. Series B, Kilo CM. A Framework for Collaborative Improvement: Lessons from the Institute for Healthcare Improvement's Breakthrough Series. *Quality management in health care*. 1998;6(4):1-13.
22. Dahlgaard JJ, Mi Dahlgaard-Park S. Lean production, six sigma quality, TQM and company culture. *The TQM magazine*. 2006;18(3):263-81.
23. Pepper MP, Spedding TA. The evolution of lean Six Sigma. *International Journal of Quality & Reliability Management*. 2010;27(2):138-55.
24. Horbar JD, Rogowski J, Plsek PE, Delmore P, Edwards WH, Hocker J, et al. Collaborative quality improvement for neonatal intensive care. *Pediatrics*. 2001;107(1):14-22.
25. Birenbaum HJ, Dentry A, Cirelli J, Helou S, Pane MA, Starr K, et al. Reduction in the incidence of chronic lung disease in very low birth weight infants: results of a quality improvement process in a tertiary level neonatal intensive care unit. *Pediatrics*. 2009;123(1):44-50.
26. Chin MH, Alexander-Young M, Burnet DL. Health care quality-improvement approaches to reducing child health disparities. *Pediatrics*. 2009;124(Supplement 3):S224-S36.
27. Leatherman S, Ferris TG, Berwick D, Omaswa F, Crisp N. The role of quality improvement in strengthening health systems in developing countries. *International Journal for Quality in Health Care*. 2010;22(4):237-43.
28. Oyesola R, Shehu D, Maru I. Improving emergency obstetric care at a state referral hospital, Kebbi State, Nigeria. *International Journal of Gynecology & Obstetrics*. 1997;59(S2).
29. Djan J, Kyei-Faried S, Twum S, Danquah J, Ofori M, Browne E. Upgrading obstetric care at the health center level, Juaben, Ghana. *International Journal of Gynecology & Obstetrics*. 1997;59(S2).
30. Kayongo M, Butera J, Mboninyibuka D, Nyiransabimana B, Ntezimana A, Mukangamuje V. Improving availability of EmOC services in Rwanda—CARE's experiences and lessons learned at Kabgayi Referral Hospital. *International Journal of Gynecology & Obstetrics*. 2006;92(3):291-8.
31. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *International journal of social research methodology*. 2005;8(1):19-32.
32. Daudt HM, van Mossel C, Scott SJ. Enhancing the scoping study methodology: a large, inter-professional team's experience with Arksey and O'Malley's framework. *BMC medical research methodology*. 2013;13(1):48.
33. Pham MT, Rajic A, Greig JD, Sargeant JM, Papadopoulos A, McEwen SA. A scoping review of scoping reviews: advancing the approach and enhancing the consistency. *Res Synth Methods*. 2014;5(4):371-85.
34. Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. *Implementation science*. 2010;5(1):69.
35. Gough D, Thomas J, Oliver S. Clarifying differences between review designs and methods. *Systematic reviews*. 2012;1(1):28.
36. Tricco AC, Tetzlaff J, Moher D. The art and science of knowledge synthesis. *Journal of clinical epidemiology*. 2011;64(1):11-20.
37. Colquhoun HL, Levac D, O'Brien KK, Straus S, Tricco AC, Perrier L, et al. Scoping reviews: time for clarity in definition, methods, and reporting. *Journal of clinical epidemiology*. 2014;67(12):1291-4.

38. World Health Organization. Summary of WHO Position Papers - Recommended Routine Immunizations for Children Geneva 2018 [cited 2018 12th July 2018 at 2:38PM]. Available from: http://www.who.int/immunization/policy/Immunization_routine_table2.pdf?ua=1.
39. Effective Practice and Organization of Care (EPOC). EPOC Taxonomy 2015 [cited 2017. Available from: <http://epoc.cochrane.org/sites/epoc.cochrane.org/files/public/uploads/2015%20EPOC%20Taxonomy%20FINAL.pdf>.
40. Ripple AS. Expert Googling: best practices and advanced strategies for using Google in health sciences libraries. *Medical reference services quarterly*. 2006;25(2):97-107.
41. Freeman MK, Lauderdale SA, Kendrach MG, Woolley TW. Google Scholar versus PubMed in locating primary literature to answer drug-related questions. *Annals of Pharmacotherapy*. 2009;43(3):478-84.
42. American Academy of Paediatrics. Quality Improvement 2018 [cited 2018 14th July 2018 at 2:48pm]. Available from: <https://www.aap.org/en-us/professional-resources/quality-improvement/Pages/default.aspx>.
43. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Annals of internal medicine*. 2009;151(4):264-9.
44. Pawson R. Evidence-based policy: in search of a method. *Evaluation*. 2002;8(2):157-81.
45. Patterson BL, Gregg WM, Biggers C, Barkin S. Improving delivery of EPSDT well-child care at acute visits in an academic pediatric practice. *Pediatrics*. 2012;130(4):e988-95.
46. Shaw JS, Wasserman RC, Barry S, Delaney T, Duncan P, Davis W, et al. Statewide quality improvement outreach improves preventive services for young children. *Pediatrics*. 2006;118(4):e1039-47.
47. Chung RJ, Walter EB, Kemper AR, Dayton A. Keen on teen vaccines: improvement of adolescent vaccine coverage in rural North Carolina. *J Adolesc Health*. 2015;56(5 Suppl):S14-6.
48. Malone K, Clark S, Palmer JA, Lopez S, Pradhan M, Furth S, et al. A quality improvement initiative to increase pneumococcal vaccination coverage among children after kidney transplant. *Pediatric transplantation*. 2016;20(6):783-9.
49. Pahud B, Clark S, Herigon JC, Sherman A, Lynch DA, Hoffman A, et al. A pilot program to improve vaccination status for hospitalized children. *Hosp Pediatr*. 2015;5(1):35-41.
50. Perkins RB, Zisblatt L, Legler A, Trucks E, Hanchate A, Gorin SS. Effectiveness of a provider-focused intervention to improve HPV vaccination rates in boys and girls. *Vaccine*. 2015;33(9):1223-9.
51. Harris JG, Maletta KI, Ren B, Olson JC. Improving Pneumococcal Vaccination in Pediatric Rheumatology Patients. *Pediatrics*. 2015;136(3):e681-6.
52. Daley MF, Steiner JF, Kempe A, Beaty BL, Pearson KA, Jones JS, et al. Quality improvement in immunization delivery following an unsuccessful immunization recall. *Ambulatory pediatrics : the official journal of the Ambulatory Pediatric Association*. 2004;4(3):217-23.
53. Daly KL, Halon PA, Aronowitz T, Ross G. A University Health Initiative to Increase Human Papillomavirus Vaccination Rates. *The Journal for Nurse Practitioners*. 2016;12(6):e281-e6.
54. Fiks AG, Luan X, Mayne SL. Improving HPV Vaccination Rates Using Maintenance-of-Certification Requirements. *Pediatrics*. 2016;137(3):e20150675.

55. Jones KB, Spain C, Wright H, Gren LH. Improving Immunizations in Children: A Clinical Break-even Analysis. *Clinical medicine & research*. 2015;13(2):51-7.
56. Krantz L, Ollberding NJ, Beck AF, Carol Burkhardt M. Increasing HPV Vaccination Coverage Through Provider-Based Interventions. *Clin Pediatr*. 2018;57(3):319-26.
57. Moore KL, Fankhauser MK, Hull PC. Tennessee's 3-Star Report: Using Available Data Systems to Reduce Missed Opportunities to Vaccinate Preteens. *Biomedical informatics insights*. 2016;8(Suppl 2):15-21.
58. Rand CM, Tyrrell H, Wallace-Brodeur R, Goldstein NPN, Darden PM, Humiston SG, et al. A Learning Collaborative Model to Improve Human Papillomavirus Vaccination Rates in Primary Care. *Acad Pediatr*. 2018;18(2S):S46-S52.
59. Jones KB, Gren LH, Backman R. Improving pediatric immunization rates: description of a resident-led clinical continuous quality improvement project. *Family medicine*. 2014;46(8):631-5.
60. Sinn JS, Morrow AL, Finch AB. Improving immunization rates in private pediatric practices through physician leadership. *Archives of pediatrics & adolescent medicine*. 1999;153(6):597-603.
61. Melinkovich P, Hammer A, Staudenmaier A, Berg M. Improving pediatric immunization rates in a safety-net delivery system. *Joint Commission journal on quality and patient safety*. 2007;33(4):205-10.
62. Carlin E, Carlson R, Nordin J. Using Continuous Quality Improvement Tools to Improve Pediatric Immunization Rates. *The Joint Commission Journal on Quality Improvement*. 1996;22(4):277-88.
63. Heidi Gurov. Assessment-Feedback-Incentives-Exchange. Wyoming Immunization Conference; May 23, 2018; Wyoming, United States: Wyoming Department of Health; 2018.
64. Schneider A. How quality improvement in health care can help to achieve the Millennium Development Goals. *SciELO Public Health*; 2006.
65. Langlely GJ, Moen RD, Nolan KM, Nolan TW, Norman CL, Provost LP. *The improvement guide: a practical approach to enhancing organizational performance*: John Wiley & Sons; 2009.
66. Wandersman A, Imm P, Chinman M, Kaftarian S. Getting to outcomes: A results-based approach to accountability. *Evaluation and program planning*. 2000;23(3):389-95.
67. Eccles M, Grimshaw J, Campbell M, Ramsay C. Research designs for studies evaluating the effectiveness of change and improvement strategies. *BMJ Quality & Safety*. 2003;12(1):47-52.
68. Cook TD, Campbell DT, Shadish W. *Experimental and quasi-experimental designs for generalized causal inference*: Houghton Mifflin Boston; 2002.
69. Patsopoulos NA. A pragmatic view on pragmatic trials. *Dialogues Clin Neurosci*. 2011;13(2):217-24.
70. Roland M, Torgerson DJ. Understanding controlled trials: What are pragmatic trials? *Bmj*. 1998;316(7127):285.
71. Curran GM, Bauer M, Mittman B, Pyne JM, Stetler C. Effectiveness-implementation hybrid designs: combining elements of clinical effectiveness and implementation research to enhance public health impact. *Med Care*. 2012;50(3):217-26.
72. Brown P, Brunnhuber K, Chalkidou K, Chalmers I, Clarke M, Fenton M, et al. How to formulate research recommendations. *Bmj*. 2006;333(7572):804-6.
73. Ogrinc G, Davies L, Goodman D, Batalden P, Davidoff F, Stevens D. SQUIRE 2.0 (Standards for QQuality Improvement Reporting Excellence): revised publication guidelines from a detailed consensus process. *The Journal of Continuing Education in Nursing*. 2015;46(11):501-7.

Supplementary Material 3.1

PUBMED

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AND

quality improvement[mh] OR (quality[tiab] AND (system*[tiab] OR process*[tiab] OR improvement*[tiab] OR enhancement*[tiab] OR strateg*[tiab] OR intervention*[tiab] OR management[tiab])) OR implementation strateg*[tiab] OR implementation process*[tiab]

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AND

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AND

Missed[tiab] AND opportunit*[tiab]

WEB OF SCIENCE (1970 – 2018)

ts=(infant OR toddler* OR preterm* OR prematur* OR baby OR babies OR neonat* OR newborn OR preschool* OR pre-school* OR child OR child* OR kindergar* OR pupil* OR schoolchild* OR teen* OR youth OR youths OR youngster* OR young person* OR young people OR minors OR minors OR puberty OR pubescen* OR prepubescen* OR paediatric* OR pediatric* OR peadiatric* OR kid OR boy* OR girl* OR creche* OR highschool* OR “secondary school” OR juvenil* OR adolescent OR adolescen*)

AND

ts=(“quality improvement” OR “quality system*” OR “quality network*” OR “quality process*” OR “quality improvement*” OR “quality enhancement*” OR “quality strateg*” OR “quality intervention*” OR “quality management” OR “implementation strategy*” OR “implementation process”)

OR

ts=(“Plan do study act” OR “plan do check act” OR “define measure analyze improve control” OR “define measure analyse improve control” OR “define measure analyse design verify” OR “define measure analyze design verify” OR lean OR “six sigma”)

AND

ts=(Immunization OR immuni* OR vaccin* OR revaccin* OR innoculat* OR inoculat*)

AND

ts=(“missed opportunities for vaccination” OR “missed opportunities for immunization” OR Missed near/3 opportunit*)

SCOPUS

TITLE-ABS-KEY (“quality improvement” OR “quality system*” OR “quality network*” OR “quality process*” OR “quality improvement*” OR “quality enhancement*” OR “quality strateg*” OR “quality intervention*” OR “quality management” OR “implementation strategy*” OR “implementation process*” OR “Plan do study act” OR “plan do check act” OR “define measure analyze improve control” OR “define measure analyse improve control” OR “define measure analyse design verify” OR “define measure analyze design verify” OR lean OR “six sigma”)

TITLE-ABS-KEY (infant OR toddler* OR preterm* OR prematur* OR baby OR babies OR neonat* OR newborn OR preschool* OR pre-school* OR child OR child* OR kindergar* OR pupil* OR schoolchild* OR teen* OR youth OR youths OR youngster* OR young person* OR young people OR minors OR minors OR puberty OR pubescen* OR prepubescen* OR paediatric*] OR pediatric* OR peadiatric* OR kid OR boy* OR girl* OR creche* OR highschool* OR “secondary school” OR juvenil* OR adolescent OR adolescen*)

TITLE-ABS-KEY (Immunization OR immuni* OR vaccin* OR revaccin* OR innoculat* OR inoculat*)

Chapter 4: A multilevel analysis of the determinants of missed opportunities for vaccination among children attending primary healthcare facilities in Kano, Nigeria: findings from the pre-implementation phase of a collaborative quality improvement programme.

4.0 About this chapter

In this chapter we report a quantitative study using multilevel modeling to explore the determinants of missed opportunities for vaccination in the pre-implementation phase of a quality improvement programme in Kano, Nigeria. This chapter has been published by Public Library of Science (PLOS) in *PLOS ONE* on 10th July 2019, and can be accessed through the following link: <https://doi.org/10.1371/journal.pone.0218572>. The full citation is as follows: Abdu A Adamu, Olalekan A Uthman, Muktar A Gadanya, Olatunji O Adetokunboh, & Charles S Wiysonge. A multilevel analysis of the determinants of missed opportunities for vaccination among children attending primary healthcare facilities in Kano, Nigeria: Findings from the pre-implementation phase of a collaborative quality improvement programme. *PLoS ONE* 14(7): e0218572. DOI: [10.1371/journal.pone.0218572](https://doi.org/10.1371/journal.pone.0218572). Epub 2019 Jul 10.

4.1 Abstract

Background: We aimed to determine the factors that are responsible for MOV among children aged 0 – 23 months attending primary health care (PHC) facilities in Nassarawa, Kano State, Nigeria.

Method: This cross-sectional study was conducted in the pre-implementation phase of a quality improvement (QI) programme. One-stage cluster sampling technique was employed. Data were collected from caregivers of children aged 0 – 23 months in ten randomly selected PHC facilities. Semi-structured, interviewer administered questionnaires were used. Frequencies and percentages were used to summarize the data. Multilevel logistic regression

model with fixed effect and random effect component was fitted to obtain measures of association and variation respectively.

Result: Caregivers of 675 children responded. Among these children, the prevalence of MOV (for at least one antigen) was 36.15%. MOV (for individual antigens) was highest for inactivated polio vaccine, followed by measles vaccine. The random effect model yielded an intraclass correlation coefficient of 9.60% for the empty model. The fixed effect model revealed that MOV was more likely among children that were incidentally accompanying a caregiver to the health facility (OR=2.86, 95%CrI: 1.28 to 5.80) (i.e. not for health care themselves) compared to those that were visiting the health facility for medical consultation. Failure to offer vaccination on day of visit (OR=2.32, 95%CrI: 1.12 to 4.12) and visiting a clinic with three or more vaccinators (OR=12.91, 95%CrI: 4.82 to 27.14) increased the likelihood of MOV.

Conclusion: This study identified important local factors that are responsible for MOV which can be addressed in the QI programme.

4.2 Introduction

Vaccines can improve the health of children and increase life expectancy by reducing the burden of death and disability caused by common infectious diseases (1, 2). In order to extend this benefit to all children, Nigeria established an Expanded Programme on Immunization (EPI) (3). Currently, the programme provides routine immunization with the following vaccines: Bacillus Calmette-Guerin (BCG), oral polio vaccine (OPV), hepatitis B vaccine (HBV), pentavalent vaccine (diphtheria, tetanus, pertussis, hemophilus influenzae type b and hepatitis b virus containing vaccine, pneumococcal conjugate vaccine (PCV), inactivated polio vaccine (IPV), measles vaccine and yellow fever vaccine (4). These vaccines are provided within the first year of life according to the national immunization schedule as follows: at birth (BCG, OPV0, HEPB0), at six weeks of age (Penta1, OPV 1, PCV1), at 10 weeks of age (Penta2, OPV2, PCV2), at 14 weeks of age (Penta3, OPV3, PCV3, IPV), and at nine months of age (measles and yellow fever) (4). However, a significant number of children in the country are still unimmunized and full childhood immunization coverage is suboptimal (3, 5-7). Even within the country, there is disparity in coverage level between geopolitical zones, with the North West zone reporting full immunization coverage level of 8% compared to 50% in the South West (8). In Kano, which is one of the states in North West zone, full immunization coverage is only 10% and coverage with third dose of pentavalent vaccine is 16% (8). Kano is highly populated, and the persistently poor coverage level has made it a high-risk state for polio transmission (9, 10). Several factors contribute to low immunization coverage among which are missed opportunities for vaccination (MOV) in health service settings (11-14).

MOV refers to any contact with health services by an unvaccinated or partially vaccinated child (who is free of contraindications) which does not result in the child receiving all the recommended vaccine doses for their age according to the national schedule (11, 15). Studies conducted in tertiary hospitals in Benin, Anambra and Enugu, Nigeria reported MOV prevalence of 27.6%, 17% and 15.1% respectively (16-18). Furthermore, the level of “missed opportunities” for specific antigens also vary across settings. In Enugu and Benin, measles vaccines were the most commonly missed (16, 17).

To standardize the procedure for quantifying MOV, the World Health Organization (WHO) built on an existing protocol to develop an updated MOV methodology (19, 20). In the current MOV strategy, assessments are focused on children aged 0 – 23 months (19, 20). The

procedure involves interviewing caregivers while exiting health facilities and obtaining the immunization history of children from their home-based records (HBR) (21). As illustrated in **Figure 4.1**, a “missed child” either didn’t receive any vaccine or received only some of their recommended vaccine doses.

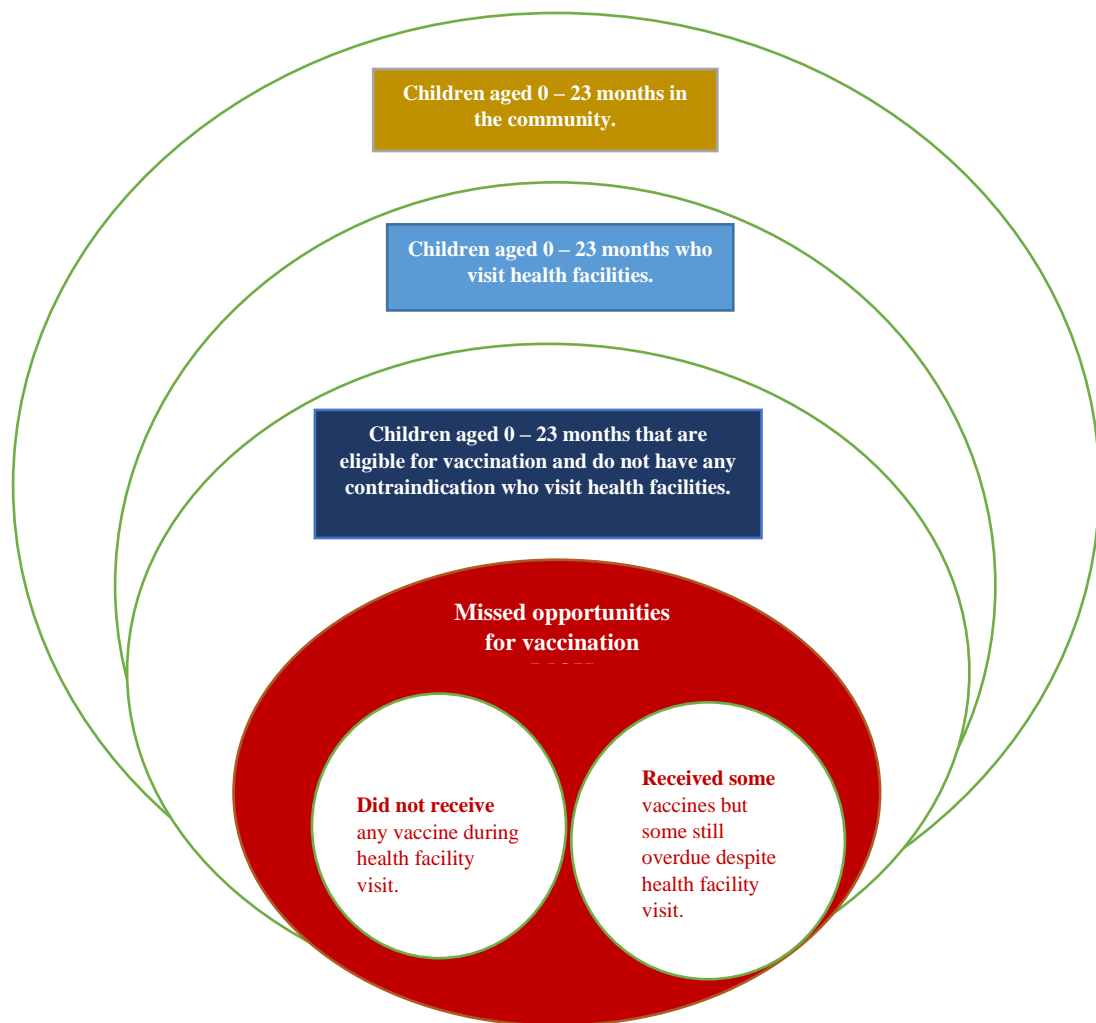


Figure 4.1: Euler diagram of missed opportunities for vaccination

Understanding the magnitude and factors that are responsible for MOV among children aged 0 – 23 months is relevant for practice and policy and can inform the development of interventions. A recent systematic review and meta-analysis, which included three studies from Nigeria (conducted in the South East and South South geopolitical zones) estimated the pooled prevalence of MOV among African children aged 0 – 23 months to be 27.26% (22). In addition, the review highlighted several determinants of MOV and importantly, depicted

the complexity of the problem by showing that factors are interrelated and interdependent using a causal loop diagram (22). However, only 20 studies from 14 African countries were included (22). So far, there is limited evidence from Kano, despite being a low immunization coverage setting.

In this study the prevalence of MOV and its determinants were explored among caregivers attending primary health care (PHC) facilities in Kano State, Nigeria. This was to generate context-specific information that can be used by local immunization stakeholders and health workers in a quality improvement (QI) programme. Quality improvement (QI) is an approach for instituting rapid change in health systems through continuous effort and experiential learning in order to improve health outcomes (23). It can be used to redesign health delivery systems like immunization services to improve uptake and reduce MOV (24).

Existing literature suggests that MOV occur in facilities where individual level factors originating from children and caregivers co-occur with health systems factors that affect immunization service delivery (22). Since the influence of these contextual predictors differ across setting, the magnitude of MOV can vary, with a resultant clustering effect in facilities. To explore this, a multilevel modeling framework was adopted. Conceptually, individuals (child and caregiver) were considered to be nested in health facilities. In line with this assumption, the determinants of MOV were also categorized into two, namely; individual- and health facility-related factors. The selection of these factors was informed by previous studies as well as background knowledge of the context (21, 22). **Figure 4.2** shows the conceptual framework. This study focused on primary healthcare facilities because this level of healthcare is closest to people and communities (25). It also has immunization as part of its key service components (25).

The specific objective of this study was to determine factors responsible for missed opportunities for vaccination among children aged 0 – 23 months attending primary healthcare facilities in Nassarawa, Kano State.

HEALTH FACILITY-RELATED FACTORS

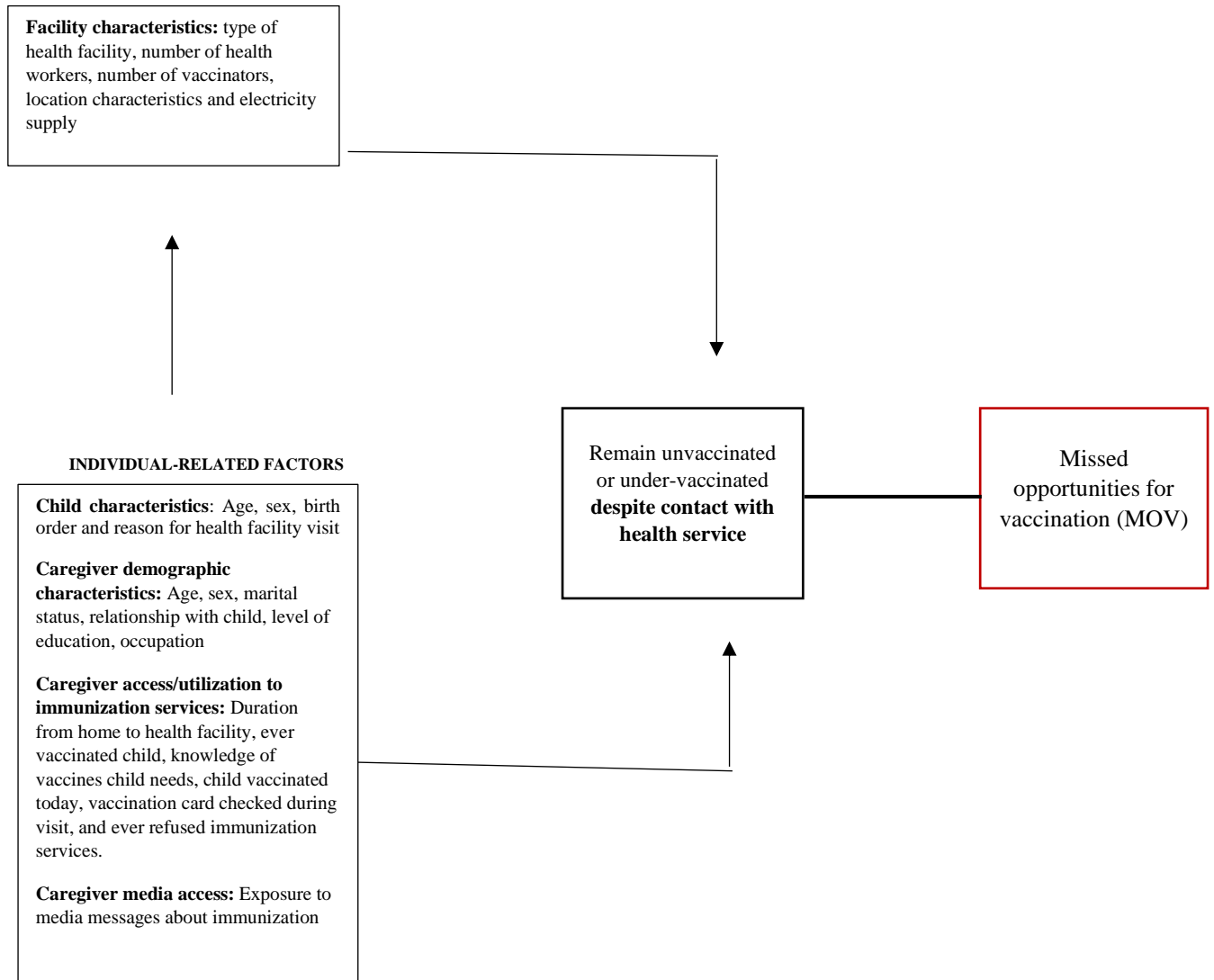


Fig. 2: Multilevel conceptual framework of the determinants of missed opportunities for vaccination among children aged 0 – 23 months attending primary healthcare facilities in Nassarawa, Kano State

4.3 Methodology

4.3.1 Study design

A cross-sectional study design was used (26). This was conducted in the pre-implementation phase of a collaborative QI programme. This observational study design enabled the measurement of the burden of MOV and its determinants at a specific point in time thus providing a snapshot of the phenomenon (26).

4.3.2 Study setting

The study was conducted in Nassarawa LGA, which is one of the metropolitan LGAs in Kano (27). This LGA has an area of 35km² with a high prevalence of slum settlements (28). According to the 2006 National Housing and Population Census, the population of Nassarawa was 596,669, with an estimated annual growth rate of 3.3% (29, 30). The 2018 projected population of the LGA is 880,922. In addition, the projected population of children under one year of age and under five years of age are 35,236 and 176,184 respectively. Nassarawa LGA is further subdivided into 11 administrative wards. There are 18 public primary health care (PHC) facilities in the LGA that offer immunization services. According to the current minimum standards for primary health care (PHC) in Nigeria, these primary health care facilities are classified into primary health centers, primary health clinics, and health posts (25).

4.3.3 Study population

Children aged 0 – 23 months who were brought to public PHC facilities in Nassarawa LGA by a caregiver (aged 18 years and above) were included in this study. In situations where a caregiver came to the health facility with more than one child, only the youngest child was considered to avoid overrepresentation.

4.3.4 Sampling

Study participants were drawn from ten randomly selected public PHC facilities that provide immunization services in the LGA. One-stage cluster sampling technique was used. Each public primary health care facility was considered as a cluster. Within each cluster, all

children aged 0 – 23 months who were brought to the facility during a specified period by an eligible and consenting caregiver were selected.

4.3.5 Sample size

The required sample size of children aged 0 – 23 months was 675. This was computed using Cochran's equation for sample size, and based on the following assumptions: critical value of 1.96 (at 95% confidence level), a prevalence of MOV of 32.2% from a previous study, an accepted margin of error of 5%, non-response rate of 20% and design effect of 1.5 (15, 31, 32). Design effect (Deff) was considered in order to account for clustering as respondents are embedded within specific primary health care facilities (33).

4.3.6 Data collection

Data was collected using an interviewer administered semi-structured questionnaire. This questionnaire was adapted from WHO's caregiver quantitative data collection tool as specified in the methodology for the assessment of MOV (attached as Appendix 1) (19, 20). The caregiver tool had already been pilot tested by WHO (34). Before commencing data collection, the questionnaire was translated into Hausa Language and both versions were pre-tested in Kano Municipal and Kumbotso to ensure clarity and suitability of questions. Advocacy visits were paid to state and local government immunization stakeholders. This was to seek their buy-in and solicit for collaboration throughout the QI process. A one-day training of data collectors was conducted. During the training, each item on the questionnaire was discussed to ensure common understanding. Repeated dry runs were performed to improve their familiarity with the tool. Ethical considerations were also discussed. Face-to-face health facility exit interviews that were conducted between December 17 - 21, 2018 was used for this study. Data collection was usually between 8:00AM and 4:00PM and on weekdays only. The caregivers of all eligible children attending the PHC facilities were interviewed. Interviews were conducted by the trained data collectors in either English or Hausa Language depending on the preference of the respondent. The data collectors were fluent in both languages. After collecting information from the caregiver, the child's immunization history was then obtained from their home-based record (HBR) also called "vaccination card" in this setting or any temporary vaccination document. The data collectors did not have any prior training on immunization. Research electronic data capture (REDCap) was used for collecting and managing the data collected for this study (35).

4.3.7 Variables

Outcome variables: MOV for at least one antigen was used as the main outcome variable. This was a binary variable coded as 1,0 for MOV and no MOV respectively.

Explanatory variable: The explanatory variables were grouped into two levels as follows:

Level 1: child's age group, child's sex, birth order, reason for child's visit to health facility, caregiver's age, caregiver's sex, marital status, relationship with child, occupation, level of education, duration from home to health facility, exposure to media messages about immunization, ever vaccinated child, ever refused immunization in health facility, vaccination card checked during this visit, knowledge of vaccines child needs and child vaccinated today.

Level 2: type of primary health care facility (primary health care clinic and primary health care center) number of health workers, number of vaccinators, location characteristics and electricity supply.

4.3.8 Data analysis

The frequency and percentage of children with MOV (for at least one antigen) were calculated. Also, frequencies and percentages of MOV for each antigen were calculated. To account for the effect of clustering, *surveyset* command in Stata was specified before calculations (36, 37). All the explanatory variables (individual and health services-related factors) were summarized using frequencies and percentages. Since clustered data were collected, assumption of independence would not hold. Therefore, to obtain correct standard errors for the measures of association between individual and health facility-related factors and MOV, as well as between-PHC facility variance, a multilevel logistic regression model was used (38). Multilevel models are an extension of generalized linear models which address non-independence in data by generating cluster-specific random models (39). In this model, we regarded individuals (children and caregivers) as level 1 and considers them as nested in primary health care facilities (level 2) (40).

In total, four models were built. In model 1, only health facility random intercept was included to estimate between-facility variance, thus the probability of MOV in this model was only a function of the health facility that a child attended. Model 2 included only

individual-related factors (level one explanatory variables), and model 3, included only health facility-related factors. Finally, model 4, which is the full model, controlled for both individual and health facility-related factors. The models were fitted using Markov Chain Monte Carlo (MCMC) method (41). In this method, a Markov chain makes successive selections of subsets of parameters from their posterior distributions (41). The estimation setting was inputted manually to achieve a burn-in period of 10,000 iterations followed by a monitoring period of 5000 iterations (41). Odd ratios with corresponding 95% credible intervals (CrI) were reported for the fixed effects. While for the random effect, variance, intraclass correlation coefficient (ICC) and mean odds ratios (MOR) were reported to quantify the influence of context. ICC was presented as percentages to represent the total variance in the probability of MOV that is accounted for by health facilities. While MOR represented total variance in the probability of MOV that is attributed to health facilities in the odds ratio scale. The deviance information criterion (DIC) was used to assess the model fit (42). Lower DIC indicated a better fit (42). Models were built in MLwiN version 3.01 from Stata 14.2 using *runmlwin* command (41).

4.3.9 Ethical approval

Ethical clearance for this study (with reference number: S18/02/044) was obtained from Stellenbosch University Health Research Ethics Committee (attached as **Appendix 5**). Also, the study was approved by research ethics committees at Kano State Ministry of Health (with reference number: MOH/Off/797/T.I/374) (attached as **Appendix 6**) and Aminu Kano Teaching Hospital (with reference number: NHREC/21/08/2008/AKTH/EC/2296) (attached as **Appendix 7**). An information sheet was read to respondents and written informed consent was obtained. The study participants were informed that they could choose not to answer any question or leave the study at any time. No identifiers were collected to ensure anonymity.

4.4 Results

The total number of children aged 0 – 23 months included in this study was 675. Caregivers of children were interviewed across all ten primary healthcare facilities in Nassarawa LGA, Kano.

4.4.1 Burden of MOV

The prevalence of MOV (for at least one antigen) among children aged 0 – 23 months attending primary healthcare facilities in Nassarawa LGA was 36.15%. The prevalence of MOV for inactivated polio vaccine (IPV) and measles vaccines were 45.10% and 43.28% respectively. MOV prevalence for all the other antigens are shown in **Table 4.1**.

Table 4.1: Prevalence of missed opportunities for vaccination (MOV) among children aged 0 – 23 months attending primary healthcare facilities in Nassarawa LGA, Kano

Variables	Total (N)	Frequency (n)	Percentage (%)
MOV for one or more antigens			
MOV (1+)	675	244	36.15
MOV for each dose of antigen			
Bacillus Calmette-Guerin (BCG)	670	23	3.43
Hepatitis B Vaccine (HBV)	667	58	8.70
Birth Dose Oral Polio Vaccine (OPV0)	667	48	7.20
First Dose Oral Polio Vaccine (OPV1)	475	91	19.16
Second Dose Oral Polio Vaccine (OPV2)	365	103	28.22
Third Dose Oral Polio Vaccine (OPV3)	286	115	40.21
First Dose Pentavalent Vaccine (PENTA1)	470	102	21.70
Second Dose Pentavalent Vaccine (PENTA2)	368	106	28.80
Third Dose Pentavalent Vaccine (PENTA3)	281	110	39.15
First Dose Pneumococcal Conjugate Vaccine (PCV1)	475	106	22.32
Second Dose Pneumococcal Conjugate Vaccine (PCV2)	369	114	30.89
Third Dose Pneumococcal Conjugate Vaccine (PCV3)	287	120	41.81
Inactivated Polio Vaccine (IPV)	286	129	45.10
Measles Vaccine (MCV)	134	58	43.28
Yellow Fever Vaccine (YFV)	135	56	41.48

MOV1+ = missed opportunities for vaccination for at least one antigen

N = number of children that are eligible immunization

A total of 589 children in this study were aged 0 – 11 months, while 86 were aged 12 – 23 months. Among all the children, 52.83% were males. The commonest reason for bringing

children to the health facility was for vaccination. Most caregivers were females and 55.85% of caregivers completed secondary education. Majority of children have ever been vaccinated before and 86.76% of caregivers said they know the vaccines that their children require.

Other characteristics are shown in **Table 4.2**.

Table 4.2: Characteristics of children aged 0 – 23 months and their caregivers attending primary health care facilities in Nassarawa LGA, Kano

Variables	Total Frequency		MOV	
	Number (n)	Percentage (%)	Yes Number (n)	No Number (n)
INDIVIDUAL-LEVEL FACTORS				
Child's age group				
0 - 11 months	589	87.26	200	389
12 - 23 months	86	12.74	44	42
Child's sex				
Male	355	52.83	121	234
Female	317	47.17	122	195
Birth order				
First child	176	26.07	52	124
Second child	135	20.00	58	77
Third child and above	364	53.93	134	230
Reason for child's visit to health facility				
Medical consultation or hospitalization	170	25.26	84	86
Vaccination	386	57.36	106	280
Only accompanying caregiver	64	9.51	39	25
Newborn or growth and development clinic	53	7.88	15	38
Caregiver's age group				
18 - 24 years	261	38.67	101	160
25 - 31 years	276	40.89	97	179
>31 years	138	20.44	46	92
Caregiver's sex				
Male	29	4.31	17	12
Female	644	95.69	225	419
Marital status				
Married	648	96	234	414
Unmarried	27	4	10	17

Variables	Total Frequency		MOV	
	Number (n)	Percentage (%)	Yes Number (n)	No Number (n)
Occupation				
Housewife	547	82.01	194	353
Employed	99	14.84	37	62
Student	21	3.15	8	13
Level of education				
No formal education or didn't complete primary school	101	14.96	33	68
Completed primary school	113	16.74	46	67
Completed secondary school	377	55.85	133	244
Post-secondary education	84	12.44	32	52
Duration from caregiver home to health facility				
Within 30 minutes	648	96.00	241	407
More than 30 minutes	27	4.00	3	24
Exposure to media messages about immunization in the last month				
Yes	583	86.76	209	374
No	89	13.24	34	55
Ever vaccinated child				
Yes	655	97.76	233	422
No	15	2.24	10	5
Ever refused immunization in health facility				
Yes	14	2.07	10	4
No	661	97.93	234	427
Vaccination card checked during this visit				
Yes	537	80.03	183	354
No	134	19.97	60	74
Knowledge of vaccines child needs				
Yes	583	86.76	204	379
No	47	6.99	20	27
Not sure	42	6.25	19	23
Child vaccinated today				

Variables	Total Frequency		MOV	
	Number (n)	Percentage (%)	Yes Number (n)	No Number (n)
Yes	443	66.22	127	316
No	226	33.78	115	111

*MOV = Missed opportunities for vaccination

The percentage of children who attended a primary health center was 74.22%, while 25.78% attended a primary health clinic. Majority of the health facilities have more than 12 health workers. Also, majority have at least three vaccinators. Other characteristics of the health facilities are shown on **Table 4.3**.

Table 4.3: Characteristics of public primary health care facilities that provide immunization services in Nassarawa LGA, Kano

Variables	Total Frequency		MOV	
	Number (n)	Percentage (%)	Yes Number (n)	No Number (n)
HEALTH FACILITY-LEVEL FACTORS				
Type of primary health facility				
Primary health centre	501	74.22	168	333
Primary health clinic	174	25.78	76	98
Number of health workers				
Less than 12	54	8.00	23	31
12 or more	621	92.00	216	405
Number of vaccinators				
Less than 3	126	18.67	26	100
3 or more	549	81.33	218	331
Location characteristics				
Slum	365	54.07	128	237
Non-slum	310	45.93	116	194
Electricity supply				
None	153	22.67	67	86

1hours - 8hours	305	45.19	116	189
More than 8 hours	217	32.15	61	156

*MOV = Missed opportunities for vaccination

4.4.2 Factors associated with missed opportunities for vaccination

Measure of association: The Odds ratio (OR) with credible interval (CrI) for covariates in each model are shown on **Table 4.4**. Model 4 which adjusted for all covariates revealed that reason for health facility visit, duration from home to health facility, vaccination on day of visit, and number of vaccinators in health facilities were associated with MOV. Children who were only accompanying a caregiver to the health facility were more likely to have MOV compared to those who were visiting for medical consultation or hospitalization (OR = 2.86, 95%CrI: 1.28 to 5.80). MOV was less likely in those who were visiting the health facility for vaccination (OR=0.47, 95%CrI: 0.23 to 0.85) or attending newborn growth and development clinic (OR=0.40, 95%CrI: 0.16 to 0.79) compared to those who were visiting the PHC facility? for medical consultation. MOV was also less likely among children of caregiver who reported that the duration from their home to the health facility was more than 30 minutes (OR=0.16, 95%CrI: 0.02 to 0.48). Children who were not offered vaccination on the day of contact with the health facility were more likely to have MOV compared to those who were offered vaccination (OR=2.32, 95%CrI: 1.12 to 4.12). Children attending facilities with at least three vaccinators had more likelihood of MOV (OR=12.91, 95%CrI: 4.82 to 27.14). Odd Ratios for other variables for each model are shown in **Table 4.4**.

Table 4.4: Factors associated with missed opportunities for vaccination among children aged 0 – 23 months attending primary healthcare facilities in Nassarawa LGA, Kano

	Model 1		Model 2		Model 3		Model 4	
	OR (95%CrI)	p-value	OR (95%CrI)	p-value	OR (95%CrI)	p-value	OR (95%CrI)	p-value
FIXED-EFFECT								
INDIVIDUAL-LEVEL FACTORS								
Child's age group								
0 - 11 months			ref				ref	
12 - 23 months	-		1.76 (0.96 - 3.02)	0.04	-		1.65 (0.90 - 2.77)	0.06
Child's sex								
Male			ref				ref	
Female	-		1.27 (0.87 - 1.80)	0.12	-		1.28 (0.85 - 1.85)	0.13
Birth order								
First child			ref				ref	
Second child	-		1.92 (1.03 - 3.25)	0.02	-		1.82 (1.00 - 3.01)	0.03
Third child and above	-		1.81 (0.97 - 2.96)	0.03	-		1.74 (0.93 - 2.98)	0.04
Reason for child's visit to health facility								
Medical consultation or hospitalization			ref				ref	
Vaccination	-		0.50 (0.27 - 0.85)	0.01	-		0.47 (0.23 - 0.85)	0.01
Only accompanying caregiver	-		2.70 (1.18 - 5.36)	0.01	-		2.86 (1.28 - 5.80)	0.00
Newborn or growth and development clinic	-		0.42 (0.17 - 0.84)	0.01			0.40 (0.16 - 0.79)	0.01
Caregiver's age group								

18 - 24 years		ref			ref	
25 - 31 years	-	0.67 (0.40 - 1.04)	0.04	-	0.67 (0.40 - 1.07)	0.05
>31 years	-	0.82 (0.43 - 1.45)	0.22	-	0.85 (0.42 - 1.56)	0.25
Caregiver's sex						
Male		ref			ref	
Female	-	0.49 (0.15 - 1.09)	0.04	-	0.50 (0.19 - 1.22)	0.05
Marital status						
Married		ref			ref	
Unmarried	-	0.88 (0.30 - 1.20)	0.30	-	0.85 (0.29 - 1.95)	0.29
Occupation						
Housewife		ref			ref	
Employed	-	0.94 (0.27 - 2.80)	0.37	-	0.88 (0.40 - 1.67)	0.30
Student	-	1.05 (0.63 - 2.45)	0.42	-	1.01 (0.26 - 2.65)	0.40
Level of education						
No formal education or didn't complete primary school		ref			ref	
Completed primary school	-	1.31 (0.63 - 2.45)	0.28	-	1.22 (0.57 - 2.27)	0.35
Completed secondary school	-	1.14 (0.60 - 2.03)	0.40	-	1.07 (0.53 - 1.88)	0.47
Post-secondary education	-	1.09 (0.40 - 2.48)	0.49	-	1.02 (0.36 - 2.37)	0.42
Duration from caregiver home to health facility						
Within 30 minutes		ref			ref	
More than 30 minutes	-	0.17 (0.03 - 0.47)	0.001	-	0.16 (0.02 - 0.48)	0.00

**Exposed to media messages
about immunization in the
last month**

Yes		ref			ref	
No	-	1.42 (0.73 - 2.50)	0.16	-	1.20 (0.64 - 2.10)	0.34

Ever vaccinated child

Yes		ref			ref	
No	-	2.95 (0.66 - 9.20)	0.10	-	2.81 (0.68 - 8.85)	0.11

**Ever refused immunization in
health facility**

Yes		ref			ref	
No	-	0.47 (0.08 - 1.46)	0.08	-	0.43 (0.09 - 1.27)	0.06

**Vaccination card checked
during this visit**

Yes		ref			ref	
No	-	0.86 (0.46 - 1.50)	0.25	-	0.89 (0.48 - 1.53)	0.29

**Knowledge of vaccines child
needs**

Yes		ref			ref	
No	-	1.33 (0.61 - 2.51)	0.27	-	1.36 (0.62 - 2.55)	0.27
Not sure	-	1.75 (0.74 - 3.55)	0.13	-	1.79 (0.69 - 3.71)	0.11

Child vaccinated today

Yes		ref			ref	
No	-	2.18 (1.12 - 3.90)	0.01	-	2.32 (1.12 - 4.12)	0.02

**HEALTH FACILITY-
LEVEL FACTORS****Type of primary health
facility**

Primary health centre		ref		ref	
Primary health clinic	-	2.58 (1.12 - 7.04)	0.01	1.98 (0.94 - 4.17)	0.04

Number of health workers

Less than 12		ref		ref	
12 or more	-	1.96 (0.59 - 5.19)	0.14	2.90 (0.76 - 6.92)	0.071

Number of vaccinators

Less than 3		ref		ref	
3 or more	-	4.56 (2.12 - 10.55)	0.00	12.91 (4.82 - 27.14)	0.00

Location characteristics

Slum		ref		ref	
Non-slum	-	1.20 (0.31 - 2.41)	0.38	1.44 (0.54 - 3.63)	0.32

Electricity supply

None		ref		ref	
1hours - 8hours	-	2.61 (0.74 - 13.87)	0.11	1.99 (0.68 - 4.66)	0.12
More than 8 hours	-	0.66 (0.31 - 1.40)	0.07	0.76 (0.32 - 1.62)	0.17

Model 1 – Empty model with only random intercept

Model 2 – Individual level covariates only

Model 3 – Health facility level covariates only

Model 4 – Full model with all individual and health facility level covariates

OR = Odds ratio; CrI = Credible Interval

Measure of variation: Model one (empty model) showed that there is variation in the log odds of MOV across the 10 primary healthcare facilities (0.35, 95%CrI: 0.09 to 1.02), with an intraclass correlation (ICC) of 9.60% (**Table 4.5**). This ICC indicates that the variance in odds of MOV could be attributed to health facilities, thus suggesting the influence of context. The MOR in model 1 – 4 are 1.76, 2.07, 1.37 and 1.31 respectively. This further confirms the presence of contextual phenomenon in these primary health care facilities. The DIC for Model 4 was 796.18

Table 4.5: Random effect estimates of missed opportunities for vaccination across public primary healthcare facilities in Nassarawa LGA, Kano

	Model 1	Model 2	Model 3	Model 4
RANDOM-EFFECT				
Health facility-level				
Variance (95%CrI)	0.35 (0.09 - 1.02)	0.58 (0.16 - 1.66)	0.11 (0.00 - 0.81)	0.08 (0.00 - 0.61)
ICC (%)	9.60	15.00	3.20	2.40
MOR (%)	1.76	2.07	1.37	1.31
Explained variation (%)				
Model fit statistics				
DIC	851.41	797.55	851.03	796.18

Model 1 – Empty model with only random intercept

Model 2 – Individual level covariates only

Model 3 – Health facility level covariates only

Model 4 – Full model with all individual and health facility level covariates

OR = Odds ratio; CrI = Credible Interval; ICC = Intraclass correlation; MOR = Mean odds ratio; DIC = Deviance Information Criteria;

4.5 Discussion

4.5.1 Main findings

This current study included 675 children aged 0 – 23 months from 10 PHC facilities in Nassarawa LGA, Kano. MOV prevalence was 36.15% among children attending these PHC facilities. MOV for specific antigens was highest for IPV at 45.10%, followed by measles vaccine at 43.28%. Factors such as visiting facility for vaccination, accompanying a caregiver to facility, attending newborn, growth and development care, duration from home to health facility more than 30 minutes, receiving vaccination on day of clinic visit, and having three or more vaccinators were found to be associated with MOV. “Facility context” influenced the occurrence of MOV as ICC was found to be 9.60% in the empty model.

4.5.2 Limitations and strengths

Some limitations and strengths should be considered when interpreting the findings from this study. As a cross-sectional study, MOV and associated factors were assessed at the same time therefore assuming a cause – effect relationship may not be appropriate. Data was collected from caregivers using exit interviews in health facilities, as such, they may give socially acceptable responses thus leading to social desirability bias. Although data were clustered, multilevel analysis technique was used to model the effect of these clusters. In addition, the model that accounted for the effect of clusters was treated as a random effect model thus improving the generalizability to other PHC facilities in the local government area. Also, immunization history was obtained from home-based records thus improving the accuracy of our MOV estimates.

4.5.3 Missed opportunities for vaccination in Nassarawa LGA, Kano

Immunization is an essential evidence-based intervention that should be provided to all children who need it upon contact with health facilities (43). Although immunization uptake was found to be high among children who visited the PHC facilities where this study was conducted, many eligible children still do not receive all the recommended vaccines or vaccines doses for their age. In this study, we found an MOV prevalence of 36.15%. This is higher than previously reported prevalence level in other studies that were conducted in

Nigeria (16-18). This might be due to the difference in the level of healthcare. The current study focused on primary health care level, while earlier studies sampled children in tertiary health facilities (16-18). Another important consideration is the overall immunization coverage in the area. The states where previous studies were conducted had higher full immunization coverage level compared to where this present study was conducted (8). Regarding specific antigens, MOV was highest for IPV, followed by measles, then PCV3, yellow fever vaccine, OPV3 and PENTA3. In some previous studies, measles was reported to be the highest (16, 17). A possible explanation for why MOV was highest for these vaccines might be because they are among the last vaccines in the series and are given to older children (14). In line with WHO's recommended methodology, in this study, we only included those that are in possession of their home-based records (19). To obtain quality and reliable information about a child's immunization history, the home-based records is required (44). This study advanced existing knowledge by employing multilevel modeling approach to study MOV. The multilevel analysis technique demonstrated that facility context influence MOV occurrence. This evidence highlights the need for local immunization stakeholder and health workers to prioritize strategies that promotes the use of context-specific, tailored interventions to address MOV.

4.5.4 Implications for the quality improvement programme

Based on the MOV planning guide, assessments only constitute the initial steps in the broader MOV strategy (20). The information that are generated from facilities are to be used for improving them through follow-up interventions to reduce MOV and improve immunization coverage (20). This is why the MOV strategy is also considered an immunization strategy (20). Similarly, in this study, the MOV assessment was conducted as part of a quality improvement programme to generate information that can be used to inform the selection of locally relevant change ideas for improving the PHC facilities. This bottom-up approach is recommended by the World Health Organization (20).

The probability of MOV occurring among children who are only accompanying a caregiver to the health facility was found to be high. Although visiting a health facility for the purpose of accompanying a caregiver invariably constitute contact with health services, health workers might be reluctant to pay attention to accompanying children thus resulting in MOV. Furthermore, children who weren't provided vaccination on the day of visit were more likely to experience MOV. These two factors underscores the need for the QI programme to

broaden its scope beyond just the immunization system to the entire PHC service delivery system. Service delivery should be re-designed such that immunization services can be offered daily and screening of HBR is strengthened across all service delivery points. This can improve access to immunization for all child users of health services in the PHC facilities as well as accompanying children. Since majority of the caregivers are females, and PHC facilities offer services like family planning and antenatal care, these points should be prioritized in the QI programme. This can go hand-in-hand with a re-orientation exercise for health workers to sensitize them on the need to reduce MOV. Surprisingly, MOV was less likely among those who reported that the duration from their home to the PHC facility was more than 30 minutes. Paradoxically, children who visit facilities with higher number of vaccinators were more likely to experience MOV.

4.5.5 Implications for Broader Policy

Descriptive analysis showed that MOV occurred in more than half of children aged 12 – 23 months. And although the estimate was imprecise, the confidence interval for the association between children in their second year of life and MOV after adjusting for other covariates included some considerable likelihood of occurrence (OR=1.65, 95%CrI: 0.90 - 2.77). Therefore, this should not be ignored. The second year of life can be an important period for catch-up immunization in this setting especially for children that had earlier missed their vaccination. Therefore, there is a need for health policy makers to begin to consider policies that will institutionalize immunization within this age group.

Given the low immunization coverage level in this setting, the state primary health care management board (PHCMB) might need to consider integrating MOV assessments into the health system as a routine process to monitor this important child health quality problem and empower health workers in PHC facilities to act accordingly. This can serve as a form of “surveillance and response” mechanism that tracks and immunize unvaccinated and partially vaccinated children who make contact with facilities. Also, policy makers at the primary health care management board and ministry of health should include plans to reduce MOV into broader health sector plans to enable its consideration in the various vertical interventions that are implemented in primary health care facilities.

4.5.6 Implications for future research

This cross-sectional study highlighted that MOV is an important problem in this setting, however, the assessment was conducted in only 10 primary health care facilities in one urban LGA. Therefore, there are still several unanswered questions about the dynamics of MOV in Kano that needs to be explored. Using the Evidence Population Intervention Comparison Outcome and Time stamp (EPICOT+) framework, recommendations for future research were proposed as shown in **Box 4.1** (45). There is need for more MOV assessment in Kano, specifically, and North West Nigeria, in general. Assessments should be conducted in PHC facilities as well as other levels of health care to enable more robust understanding of this immunization sub-system problem. Furthermore, assessment should span urban and rural localities. In addition, future MOV assessments in specialized clinics like sickle cell diseases clinics, pediatric HIV clinics among others are warranted. As recommended in the planning guide, assessments should go hand in hand with site-specific interventions that can reduce MOV.

Box 4.1: Use of EPICOT+ framework to recommend future research based on gaps in evidence

Element	Recommendation(s)
Core elements	
Evidence (State of evidence)	Paucity of MOV assessments in Kano particularly, and North West Nigeria
Population (Population of interest)	MOV assessments using WHO's methodology among the following: <ul style="list-style-type: none"> - Children aged 0 – 23 months attending general hospitals - Children aged 0 – 23 months attending primary health care facilities in metropolitan local government areas. - Children aged 0 – 23 months attending primary health care facilities in rural areas. - Children aged 0 – 23 months attending specialized clinics
Interventions	Tailored interventions implemented through <ul style="list-style-type: none"> - Facility-based quality improvement

	- Collaborative quality improvement
Comparisons	Control health facilities
Outcomes	Proportion of MOV
Time stamp	January 2019
Optional element	
Study type	Cross sectional surveys

4.6 Conclusion

This study demonstrated that quantitative methods are a useful tool for identifying potential areas for intervention in a collaborative QI programme for addressing MOV in PHC facilities. Focusing on the recommended age group as specified in the updated MOV methodology streamlined data collection and target group for intervention that is aligned with the interest of immunization stakeholders. A key lesson from this study was the critical role of stakeholder engagement, particularly because it was for a QI programme. As efforts to meet target coverage level intensify, we hope that local immunization stakeholders will integrate the MOV assessments into routine health systems processes.

4.7 Competing interest

None declared

4.8 Author contribution

AAA conceptualized the study, conducted the statistical analysis and interpretation of result, and wrote the first draft of the manuscript. OOA contributed to statistical analysis and interpretation. CSW, OAU, MAG reviewed and approved the study concept, supervised and contributed to data analysis and interpretation, manuscript development. All authors approved the final manuscript.

4.9 Reference

1. Philip RK, Attwell K, Breuer T, Di Pasquale A, Lopalco PL. Life-course immunization as a gateway to health. *Expert Review of Vaccines*. 2018;17(10):851-64.
2. Delany I, Rappuoli R, De Gregorio E. Vaccines for the 21st century. *EMBO Mol Med*. 2014;6(6):708-20.
3. Ophori EA, Tula MY, Azih AV, Okojie R, Ikpo PE. Current trends of immunization in Nigeria: prospect and challenges. *Tropical medicine and health*. 2014;42(2):67-75.
4. National Primary Health Care Development Agency. The National Immunization Schedule in Nigeria Abuja, Nigeria [cited 2019 5th February 2019]. Available from: <http://nphcda.gov.ng/?ddownload=673>.
5. Adedokun ST, Uthman OA, Adekanmbi VT, Wiysonge CS. Incomplete childhood immunization in Nigeria: a multilevel analysis of individual and contextual factors. *BMC public health*. 2017;17(1):236.
6. National Primary Health Care Development Agency. Nigeria National Routine Immunization Strategic Plan 2013 - 2015. Abuja, Nigeria: Federal Ministry of Health; 2013.
7. World Health Organization. Global vaccine action plan 2011–2020. Geneva, Switzerland 2013.
8. National Primary Healthcare Development Agency and National Bureau of Statistics. Nigeria National Immunization Coverage Survey 2016/17, Final Report. Abuja, Nigeria: National Primary Healthcare Development Agency and National Bureau of Statistics; 2017.
9. National Bureau of Statistics (NBS) and United Nations Children's Fund (UNICEF). 2017 Multiple Indicator Cluster Survey 2016-17, Survey Findings Report. Abuja, Nigeria: National Bureau of Statistics and United Nations Children's Fund.
10. Abba B, Abdullahi S, Bawa S, Getso KI, Bello IW, Korir C, et al. Mobilizing political support proved critical to a successful switch from tOPV to bOPV in Kano, Nigeria 2016. *BMC public health*. 2018;18(Suppl 4):1302.
11. Hutchins SS, Jansen HA, Robertson SE, Evans P, Kim-Farley RJ. Studies of missed opportunities for immunization in developing and industrialized countries. *Bull WHO*. 1993;71(5):549-60.
12. Oleribe O, Kumar V, Awosika-Olumo A, Taylor-Robinson SD. Individual and socioeconomic factors associated with childhood immunization coverage in Nigeria. *Pan Afr Med J*. 2017;26:220.
13. Adenike OB, Adejumo J, Olufunmi O, Ridwan O. Maternal characteristics and immunization status of children in North Central of Nigeria. *Pan Afr Med J*. 2017;26:159.
14. Gunnala R, Ogbuanu IU, Adegoke OJ, Scobie HM, Uba BV, Wannemuehler KA, et al. Routine Vaccination Coverage in Northern Nigeria: Results from 40 District-Level Cluster Surveys, 2014-2015. *PLoS One*. 2016;11(12):e0167835.
15. Sridhar S, Maleq N, Guillermet E, Colombini A, Gessner BD. A systematic literature review of missed opportunities for immunization in low- and middle-income countries. *Vaccine*. 2014;32(51):6870-9.
16. Onyiriuka A. Vaccination default rates among children attending a static immunization clinic in Benin City, Nigeria. 2005.
17. Tagbo B, Onwuasigwe C. Missed immunization opportunities among children in Enugu. *Nigerian Journal of Paediatrics*. 2005;32(4):73-6.
18. Ubajaka F, Ukegbu A, Okafor N, Ejiofor O. The prevalence of missed opportunities for immunization among children utilizing immunization services in NNAMDI AZIKIWE University Teaching Hospital, NNEWI. *J Biol Agric Healthc*. 2012;6(2).

19. World Health Organization. Methodology for the Assessment of Missed Opportunities for Vaccination. Geneva, Switzerland 2017.
20. World Health Organization. Planning guide to reduce missed opportunities for vaccination. Geneva, Switzerland: World Health Organization; 2017.
21. Velandia-Gonzalez M, Trumbo SP, Diaz-Ortega JL, Bravo-Alcantara P, Danovaro-Holliday MC, Dietz V, et al. Lessons learned from the development of a new methodology to assess missed opportunities for vaccination in Latin America and the Caribbean. *BMC Int Health Hum Rights*. 2015;15(1):5.
22. Adamu AA, Sarki AM, Uthman OA, Wiyeh AB, Gadanya MA, Wiysonge CS. Prevalence and dynamics of missed opportunities for vaccination among children in Africa: applying systems thinking in a systematic review and meta-analysis of observational studies. *Expert Rev Vaccines*. 2019;18(5):547-58.
23. Batalden PB, Davidoff F. What is “quality improvement” and how can it transform healthcare? : BMJ Publishing Group Ltd; 2007.
24. Adamu AA, Uthman OA, Wambiya EO, Gadanya MA, Wiysonge CS. Application of quality improvement approaches in health-care settings to reduce missed opportunities for childhood vaccination: a scoping review. *Human vaccines & immunotherapeutics*. 2019:1-10.
25. National Primary Health Care Development Agency. Minimum standards for primary health care in Nigeria
Abuja, Nigeria: National Primary Health Care Development Agency; 2015.
26. Setia MS. Methodology Series Module 3: Cross-sectional Studies. *Indian J Dermatol*. 2016;61(3):261-4.
27. Kibon UA, Ahmed M. Distribution of Primary Health Care Facilities in Kano Metropolis Using GIS (Geographic Information System). *Research Journal of Environmental and Earth Sciences*. 2013;5(4):167-76.
28. Bobadoye SA, Fakere AA. Slum Prevalence in Nigeria: What Role for Architects? *World environment*. 2012;3(2):45-51.
29. Makama SD. 2006 National Population and Housing Census. Abuja: National Population Commission, Commission NP; 2010.
30. National Population Commission. Population and housing census of the Federal Republic of Nigeria. Priority tables. 2006;1.
31. Charan J, Biswas T. How to calculate sample size for different study designs in medical research? *Indian journal of psychological medicine*. 2013;35(2):121.
32. Israel GD. Determining sample size: University of Florida Cooperative Extension Service, Institute of Food and Agriculture Sciences, EDIS Gainesville; 1992.
33. Hulland EN, Blanton CJ, Leidman EZ, Bilukha OO. Parameters associated with design effect of child anthropometry indicators in small-scale field surveys. *Emerg Themes Epidemiol*. 2016;13:13.
34. Ogbuanu IU, Li AJ, Anya B-pM, Tamadji M, Chirwa G, Chiwaya KW, et al. Can vaccination coverage be improved by reducing missed opportunities for vaccination? Findings from assessments in Chad and Malawi using the new WHO methodology. *PloS one*. 2019;14(1):e0210648.
35. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of biomedical informatics*. 2009;42(2):377-81.
36. Lee ES, Forthofer RN. Analyzing complex survey data: Sage Publications; 2005.
37. Oyeyemi G, Adewara A, Adeyemi R. Complex survey data analysis: a comparison of SAS, SPSS and STATA. *Asian J Math Stat*. 2010;3:33-9.

38. Wong GY, Mason WM. The hierarchical logistic regression model for multilevel analysis. *Journal of the American Statistical Association*. 1985;80(391):513-24.
39. Goldstein H, Browne W, Rasbash J. Partitioning variation in multilevel models. *Understanding Statistics: Statistical Issues in Psychology, Education, and the Social Sciences*. 2002;1(4):223-31.
40. Courgeau D, Baccaini B. Multilevel analysis in the social sciences. *Popul*. 1998;10(1):39-71.
41. Leckie G, Charlton C. Runmlwin-a program to Run the MLwiN multilevel modelling software from within stata. *Journal of Statistical Software*. 2013;52(11):1-40.
42. Spiegelhalter D, Best NG, Carlin BP, van der Linde A. Bayesian measures of model complexity and fit. *Quality control and applied statistics*. 2003;48(4):431-2.
43. World Health Organization. Standards for improving the quality of care for children and young adolescents in health facilities. Geneva, Switzerland.2018.
44. World Health Organization. Home-Based Records 2019 [cited 2019 26th January 2019]. Available from: https://www.who.int/immunization/monitoring_surveillance/routine/homebasedrecords/en/.
45. Brown P, Brunnhuber K, Chalkidou K, Chalmers I, Clarke M, Fenton M, et al. How to formulate research recommendations. *BMJ*. 2006;333(7572):804-6.

Chapter 5: Using the theoretical domains framework to explore reasons for missed opportunities for vaccination among children in Kano, Nigeria: a qualitative study in the pre-implementation phase of a collaborative quality improvement programme

5.0 About this chapter

In this chapter we report a qualitative study on factors that are responsible for missed opportunities for vaccination from the perspective of caregivers. This chapter has been published by Taylor and Francis Group in *Expert Review of Vaccines* on 13th July 2019 (ahead of print), and can be accessed through the following link:

<https://doi.org/10.1080/14760584.2019.1643720>. The full citation is as follows: Abdu A Adamu, Olalekan A Uthman, Muktar A Gadanya, Sara Cooper & Charles S Wiysonge. Using the theoretical domains framework to explore reasons for missed opportunities for vaccination among children in Kano, Nigeria: a qualitative study in the pre-implementation phase of a collaborative quality improvement project. *Expert Review of Vaccines*. 2019. DOI: <https://doi.org/10.1080/14760584.2019.1643720>. Epub 2019 Jul 12.

5.1 Abstract

Background: Missed opportunities for vaccination (MOV) have been identified as an important contributor to low childhood immunization coverage. In this study, we explored the reasons for MOV from the perspective of caregivers of children aged 0 – 23 months attending primary health care (PHC) facilities in Nassarawa Local Government Area (LGA) of Kano State, Nigeria. This was to inform the implementation of a quality improvement programme to reduce MOV.

Method: An exploratory qualitative research was conducted using focus group discussions (FGD) with caregivers of children aged 0 – 23 months that visited PHC facilities. The study was conducted in three purposively selected PHC facilities in Nassarawa, Kano. The caregivers were also purposively selected from the three PHC facilities and were homogenous in terms of their place of residence. Each FGD was conducted face-to-face in a private room within the health facility. During the discussion, participants maintained a circular sitting arrangement. The FGD were audio recorded, transcribed verbatim, and analyzed using template analysis approach through the lens of the theoretical domains framework (TDF) and the capability, opportunity, motivation – behavior (COM-B) model. The researchers that conducted this study are epidemiologists and implementation scientists with experience in immunization programmes. They are multilingual, and some are fluent in both English and Hausa language. Although four of them are medical doctors, however, they do not have any affiliations or provide health services in any of the PHC facilities where this study was conducted

Result: Five FGD with 30 caregivers was conducted. The caregivers were aged between 19 and 32 years and lived within the LGA. Based on their lived experiences, several factors that are responsible for MOV were identified and categorized into three constructs based on the COM-B model. Capability encompassed caregiver's inadequate knowledge of the vaccines that children need. Opportunity included contextual factors such as non-screening of home-based records, health worker's refusal to offer immunization services, and husband's refusal due to socio-cultural beliefs. Finally, motivation included fear of the side effects of vaccination.

Conclusion: This study identified a useful framework that aided deeper insights into caregiver-related factors responsible for MOV in Nassarawa, Kano. Some of the findings from this study can be used to inform change ideas in a quality improvement programme and should be explored.

5.2 Introduction

Immunization is considered an essential and basic child health service as it protects against childhood vaccine-preventable diseases (VPD) (1-4). However, childhood immunization coverage in Nigeria has remained low, with a more dire situation in the northern states (5, 6). In Kano State, which is located in Nigeria's North West geopolitical zone, only 10% (95%CI: 7% to 13%) of children aged 12 – 23 months are fully immunized according to the 2017 National Immunization Coverage Survey (7). Although the state is a high-risk area for polio transmission, routine immunization with all doses of oral polio vaccine (OPV) is suboptimal (7, 8). Similarly, immunization coverage with first, second and third doses of pentavalent vaccine are also low at 28%, 21% and 16% respectively (7). Several factors contribute to this low immunization coverage of which missed opportunities for vaccination (MOV) has been identified as one of them (9). According to the World Health Organization (WHO), MOV refers to any health service contact by an eligible child which does not result in the child receiving the full recommended vaccine(s) for their age (9). Using Demographic and Health Survey (DHS) data from 46 countries, the prevalence of MOV among children aged 12 – 23 months was found to be 24% (10). In a systematic review and meta-analysis which included studies from 14 African countries, it was estimated that the pooled prevalence of MOV among children aged 0 – 23 months is 27.26% (11). Furthermore, a recent analysis of Nigeria's 2013 DHS data revealed that as many as 43.7% of children aged 12 – 23 months are missed for one or more vaccines (12). In addition, facility-based studies in tertiary hospitals in Benin, Anambra and Enugu reported MOV prevalence of 26.7%, 17% and 15.1% respectively (13-15). The impact of MOV on overall immunization coverage at both district and national level has positioned it as an important health systems problem, as such, it is imperative to explore the factors that are responsible for it within specific contexts.

To understand why children remain unvaccinated or partially vaccinated, researchers have proposed several conceptual frameworks (16-18). In existing frameworks, some factors are related to specific stakeholders such as caregivers and health workers, while others are cross-cutting health systems factors (18). Quantitative studies that were conducted in Nigeria have corroborated some of the suggested hypothesis in these frameworks (13-15). Also, complexity

lens have been applied to broadly explore the dynamics of the determinants for MOV and this has led to the construction of causal loop diagrams that shows how the factors are interrelated and interdependent (11). However, the underlying reasons for MOV are still poorly understood as quantitative techniques limit how the perspective of stakeholders can be explored from their individual dynamic realities (19-21). Moreover, there is a dearth of contextual literature on the reasons for MOV in Kano from the viewpoints of caregivers, despite low immunization coverage in the state (7). Therefore, a qualitative exploration of this phenomenon is warranted as it can contribute deeper insights, but in particular, theory-informed forms of qualitative inquiry (21, 22).

Using theory-based frameworks like the theoretical domains framework (TDF) can advance existing conceptual frameworks by enabling better understanding of the role and mechanism by which individual behavior influence MOV (23). The framework was developed by psychologists through a synthesis of 33 behavioral theories that are related to behavioral change (23). Behavior is regulated by a structural as well as a psychological process and using the TDF can permit their explicit description (24).

In this study, we used the validated theoretical domains framework (TDF) to explore caregiver perspectives on factors that influence uptake of immunization services among children attending primary health care (PHC) facilities in Nassarawa Local Government Area (LGA) of Kano so as to understand the reasons for MOV (25). Using the Behavior Change Wheel (BCW), we translated the influencing factors identified into recommendations for interventions to address barriers and facilitators for reducing MOV (26). The study was conducted in the pre-implementation phase of a quality improvement (QI) programme reduce MOV in PHC facilities. Quality improvement (QI) is an approach for instituting rapid change in health outcomes through implementing evidence-based interventions in an iterative manner to allow experiential learning (27). We chose PHC facilities because this level of care has provision of immunization services as one of its major functions (28, 29).

5.2.1 Theoretical framework

The theoretical domains framework (TDF) is an important integrative framework for exploring the factors that influence an outcome (25). The framework consist of 14 domains of descriptive

concepts that are related to behavior change (23). It is considered a determinant framework because its domains are hypothesized to be associated with an outcome (25). The domains include: knowledge; skills; social or professional role and identity; beliefs about capabilities; optimism; beliefs about consequence; reinforcement; intention; goals; memory, attention or decision process, environmental context and resources; social influence; emotions and behavioral regulations (23). This framework has been used across multiple contexts in the past (30-34). In South Africa, it has been used to study the barriers to the use of clinical practice guidelines in primary care setting (34). Although the TDF is useful for identifying barriers and facilitators, it cannot inform intervention design (26). As such, the Behavior Change Wheel (BCW), which was developed in order to extend the TDF so that identified barriers and facilitators could be translated into intervention recommendations is required (26). At the core of the BCW is the capability, opportunity and motivation - behavior (COM-B) model (26). This model is capable of elucidating a broad range of internal (physical and psychological) and external (contextual) mechanisms that results in a particular behavior (26). This enables the BCW to inform systematic selection of interventions based on identified factors (26).

Using the TDF domains and mapping these onto the three behavioral constructs of the COM-B model, we developed a theoretical framework (as shown in **Figure 5.1**) to understand the factors that influencing MOV among children attending PHC facilities (25, 26).

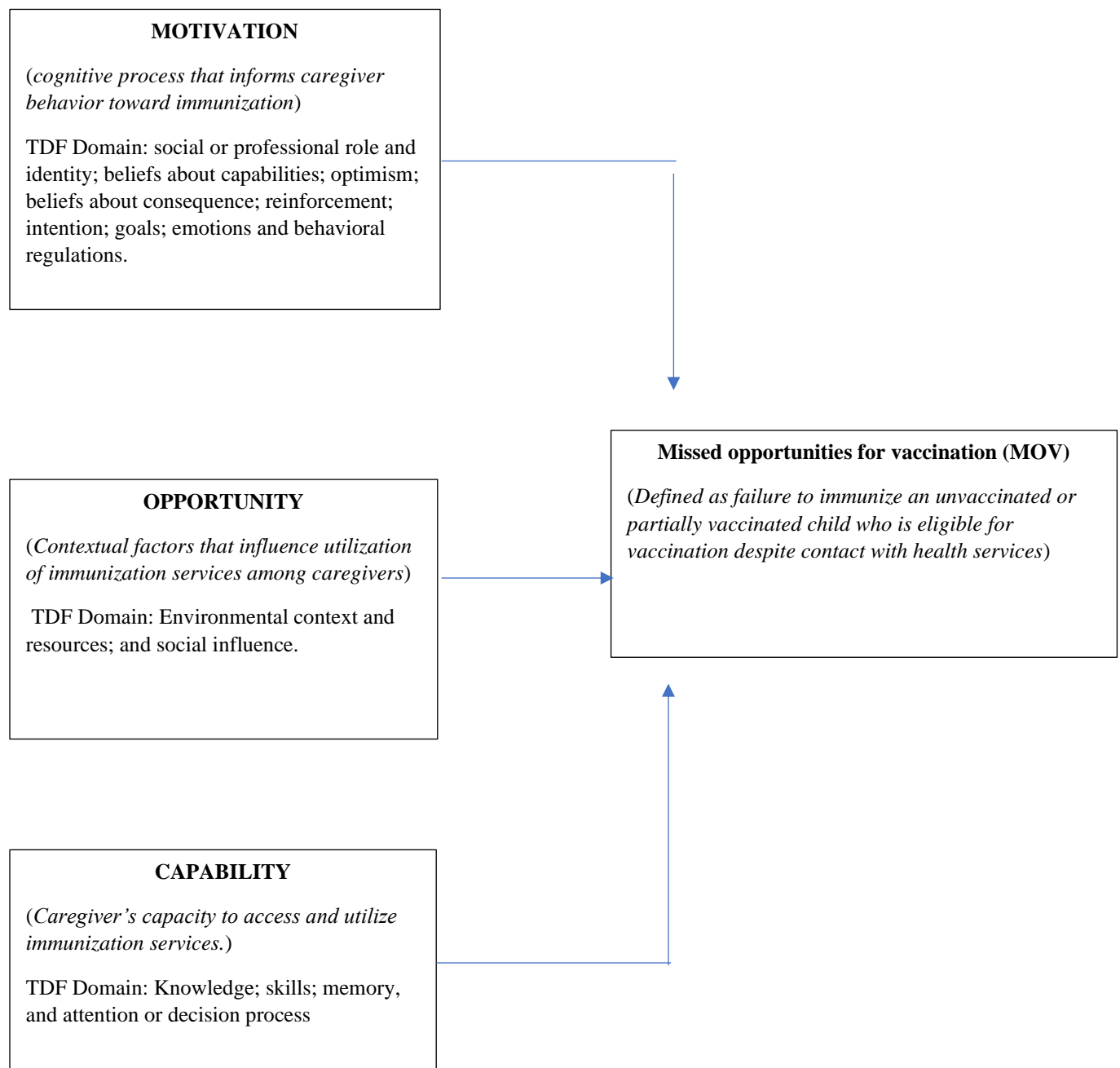


Figure 5.1: A theoretical framework for understanding caregiver-related factors that influence missed opportunities for vaccination

Capability: This was defined as caregiver's capacity to access and utilize immunization services for their child when in contact with a health facility. It comprise of domains such as knowledge; skills; memory, and attention or decision process.

Opportunity: This was defined as contextual factors (environmental and social) external to the caregiver that influence their uptake of immunization services for children when in contact with health facility. It includes domains such as environmental context and resources; and social influence.

Motivation: This was defined as caregiver's cognitive process that informs behavior toward immunization. It contain domains such as social or professional role and identity; beliefs about capabilities; optimism; beliefs about consequence; reinforcement; intention; goals; and emotions and behavioral regulations.

5.3 Methods

This qualitative analytic study was reported in accordance with the Standards for Reporting Qualitative Research (SRQR) (35).

5.3.1 Qualitative approach and research paradigm

An exploratory qualitative research design was employed (20). Epistemologically, a subtle realism paradigm was adopted because a pre-established framework (that combined TDF and COM-B) was used to understand and explain caregivers' perspectives based on their subjective perception that are informed by lived experiences (36).

5.3.2 Reflexivity

The researchers that conducted this study are epidemiologists and implementation scientists with experience in immunization programmes. They are multilingual, and some are fluent in both English and Hausa language. Although four of them are medical doctors, however, they do not have any affiliations or provide health services in any of the PHC facilities where this study was conducted. As such, the experiences and opinions shared by the caregivers are not likely to have been influenced by their profession. None of the researchers disclosed their professions to the

caregivers. All the researchers are passionate about vaccines and strongly believe that they save lives. They support policies that promote availability and uptake of vaccines in Africa and globally.

5.3.3 Context

Kano State is situated south of the Saharan desert, in the Sahelian geographical region (37). The state has an area of 20,131 km² and is subdivided into 44 local government areas (LGA) (37). Only eight LGAs are classified as urban in the state (37). Nassarawa LGA (with an area of 35km²) is one of these urban LGAs (38). Like in other parts of the state, Hausa is the dominant and most widely spoken language in Nassarawa LGA (37). According to the 2006 National Housing and Population Census, this LGA has a population of 596,669 with an annual growth rate of 3.3% (39, 40). The projected population in 2018 was estimated to be 880,922. A total of 18 public PHC facilities provide immunization services in this LGA.

5.3.4 Sampling strategy

Out of the 10 public PHCs in the LGA that are participating in the quality improvement project, three were purposively selected. Then caregivers of children aged 0 – 23 months who were attending clinics in those facilities were purposively sampled based on their areas of residence to participate in the study. In the waiting area of the facilities during peak hours which is usually at about 11:00am, the lead researcher announced their intention to have a discussion with caregivers of children aged 0 – 23 months who were aged 18 years or above and resident of Nassarawa LGA after they had been attended to by a health worker. Those who were interested then met the lead researcher after exiting the consultation room or receiving the services that they came to the facility for. Recruitment was then done on a first come basis. Once the desired number of participants per session was reached, recruitment was suspended. Only consenting caregivers were included. Pre-study meetings were held in each of the facilities to solicit the support of the “in-charges” and prepare private discussion areas.

5.3.5 Ethical approval

Ethical approval (reference number: S18/02/044) was received from Stellenbosch University Health Research Ethics Committee for this study (attached as **Appendix 5**). Also, research ethics committees at Kano State Ministry of Health (reference number: MOH/Off/797/T.I/374) and Aminu Kano Teaching Hospital (reference number: NHREC/21/08/2008/AKTH/EC/2296) approved the study (attached as **Appendix 6 and 7** respectively). An information sheet was read to respondents and written informed consent was obtained before proceeding with the focus group discussions. Each participant was informed that they could choose to leave the study whenever they want to or decline to respond to any question. To ensure confidentiality and anonymity, personal information that could identify participants were not collected. And any personal information that was found in the transcripts was removed. Facilities were also anonymized. All data pertaining to this study were safely stored on a password-protected computer.

5.3.6 Data collection

Focus group discussions (FGD) were used to obtain data from caregivers on the reasons for MOV among children. This approach promotes active communal-style interaction on a topic of interest to stimulate sharing of lived experiences (41). We decided to use FGD in this study because the approach can allow collection of personal and group perceptions regarding a phenomenon (42). In addition, it is cheaper and less time consuming compared to individual interviews (42). FGDs were conducted face-to-face in a private room within the health facilities. During the discussion, participants maintained a circular sitting arrangement. Selected caregivers were homogenous in terms of their place of residence. A total of five focus groups discussions with six participants each were conducted in Hausa language. We limited group size to six as we felt that this was logistically manageable. Each session lasted between 35 – 55 minutes. Each participant was given the opportunity to contribute during discussions.

A semi-structured discussion guide based on WHO's caregiver FGD tool was used during the FGD (attached as Appendix 1) (43). This explored caregiver experiences, and perception regarding immunization, immunization services, missed opportunities for vaccination and ways

to improve immunization services. The discussions were flexible to allow the caregivers emphasize what they considered as important and to allow further probes into unexpected topics. FGDs were facilitated by two persons; the lead researcher and an assistant.

All discussions were recorded using a portable digital audio recorder. After each discussion session, the lead researcher jotted reflections and summaries, and performed initial coding and thematic analysis to keep track of emergent themes. As at the fourth discussion, it was noted that new data were no longer being found. And after a similar pattern was observed in the fifth, it was decided that data collection be discontinued as saturation had been reached (44).

Each FGD was then transcribed verbatim and all transcripts were reviewed by the lead researcher to ensure accuracy. The transcribed discussion were translated to English and then back translated to the original language by the PI and another bilingual translator. Back translation was to ensure that no meaning was lost in translation (45). To verify translation for accuracy and completeness, the transcripts were read and reread.

5.3.7 Data analysis

Data was analyzed using template analysis approach (46). The transcripts were read repeatedly to enable thorough understanding of the data. During a subsequent reading, all internal and external behaviors that influenced caregiver uptake of immunization services for their children during clinic visits were underlined and preliminary codes generated in the process. Then these preliminary codes were compared with the coding template the researcher had developed during the discussions that reflected the questions asked and general meaning of issues raised. This eventually informed minor modification of the coding template. This thematic content analysis allowed us to inductively identify factors. Quoting was used to support each theme so as to illuminate the lived experiences of caregivers (47).

In another codebook, the 14 domains of the TDF were specified (23). After thoroughly reading the themes in the first codebook and the meaning of each domain of the TDF, the themes were extracted and deductively matched with a related domain of the TDF. Overlapping was avoided by rereading. After scrutinizing each domain, then we mapped them to the construct of the COM-B model. Once aligned, intervention functions were identified using the BCW. Finally,

another conceptual framework of factors that influence MOV was developed using factors identified from the study.

5.3.8 Trustworthiness

We ensured that our research was trustworthy and credible by describing our methodology in sufficient detail. Also, a discussion guide was used, and this was attached with the research report. The researchers have extensive experience in immunization systems and vaccinology, and this strengthened data interpretation. We adhered to the SRQR. In addition, illustrative quotes were used to help our readers interpret the data which allowed for confirmability

5.4 Findings

All participants were women who lived in the LGA. They were aged between 19 and 32 years of age. Among all participants, one of them came to the health facility with two children, although one of the children was older than 23 months. The participants were accustomed with using the health facilities for some form of curative or preventives services including immunization. Although most of them brought their children to the PHC facility for out-patient department (OPD) visits, however, majority have accessed immunization services in the past. None of them was a health worker.

To present our findings, barriers and facilitators are organized under the three constructs of the COM-B model; opportunity, motivation and capability.

5.4.1 Opportunity

This construct generated a lot of discussion among participants. We found factors that are external to caregivers strongly influence whether the child whom they have brought with them to the primary health care facility receives recommended vaccines or not. The factors that emerged include the social influence of husbands, contextual characteristics of immunization clinics, and the attitudes and behaviors of health workers regarding screening of home-based records.

Socio-cultural practices and beliefs

Regardless of their own personal desire to immunize their children, caregivers expressed that their spouse's (husband) consent is still essential for them to immunize their children, even if they're in the health facility.

“We do everything with the consent of our husbands. If they do not agree there is nothing we can do”

However, caregivers suggested that prevailing socio-cultural practices and beliefs exist that frequently dissuade men from allowing their children to be immunized:

“Some men claim that tradition does not allow them to vaccinate their children, this is why they do not allow their wives to vaccinate the children. They sometime boast that they too were not vaccinated when they were young, and nothing happened to them”

A specific fear that was shared by the caregivers in this regard was divorce. One caregiver shared her experience of a woman whose husband divorced her once he heard his child had been immunized.

“There was a woman who gave a neighbor her daughter for vaccination for fear of her husband but when the husband got to know, he divorced her”

Immunization services in clinics

An important concern that was raised was that health workers often refuse to offer immunization services if the caregiver is late or come on a day that is not designated for immunization. Some caregivers live far from clinics, and due to unforeseen circumstances, sometimes arrive late for immunization services. Others have to cook in the morning and complete house chores before being able to go to the clinic, making it difficult to arrive on time to the clinic.

“If you come late, they will ask you to come back the following week”

This situation led many caregivers to suggest that health services should review the timing of immunization services in clinics to accommodate those that might present late. Similarly, some caregivers who brought their children to the clinic after home delivery have also being refused immunization. This, for them, underscores a need for immediate change.

“There was a time I delivered my child at home and the next day I brought him for hepatitis vaccination but to my surprise they refused to do it. It was after a week I came back for BCG. This action is not good. I advise they change”

Organization of immunization services

Cost is not a reason for caregivers to not access immunization services, as such services are free. This was familiar knowledge among caregivers in all the groups. Also, in clinics that are able to take deliveries, immunization services are integrated with maternity services and provided in labor rooms. As such, children are offered birth-doses of recommended antigens immediately upon delivery:

“...if the child is delivered in the hospital, it will be done immediately”

According to the caregivers, this is essential for timely immunization of children before they even leave the health facility. Immunization services are provided in open spaces, and during cold weather, waiting for immunization can be uncomfortable for the caregivers and their children. Respondents recommended that “*canopies*” be provided to protect them from cold.

Screening of home-based records

Caregivers seldom carry their child’s home-based records (HBR) to clinics unless they are attending immunization sessions. Caregivers alluded that this can prevent children who make contact with health facilities from receiving their recommended vaccines. As a first step, one of the caregivers recommended that HBR be brought to the clinic:

“The best thing is to make sure that they carry their vaccination card to hospital any time so that health workers will specify whether the child is vaccinated”

Furthermore, children are brought to the clinics for various reasons, and according to the caregivers, if the reason for visit is not immunization, the health workers rarely ask for or check the child’s immunization status:

“The health workers do not ask whether children are vaccinated or not. They just prescribe drugs and leave”

5.4.2 Motivation

We deducted both reflective and automatic motivation towards immunizing children among the caregivers. These were informed by their optimism about immunization, beliefs about the capabilities of vaccines, beliefs about the consequences of vaccine-preventable disease especially measles, beliefs about side effects of vaccination and level of satisfaction with immunization services in facilities which serve as reinforcements.

Perception regarding common childhood diseases and the role of immunization

Respondents were able to mention a wide range of communicable and non-communicable diseases including malaria, sickle cell disease, pneumonia, chickenpox as some of the diseases that affects children in their communities. But across all FGDs, caregivers consistently identified vaccine-preventable diseases as well. One of the mothers said, *“The health problems that usually affect our children are whooping cough and measles.”* In addition, caregiver beliefs about the capabilities of immunization was overwhelmingly strong:

“... this vaccination is very important because it prevents infection from measles, cough, hepatitis, fever, pneumonia and yellow fever. We make sure our children are vaccinated because of the benefits we observed from this vaccination”

“From what I understand, vaccination is important and beneficial to our children because it prevents children from various infections”

As expressed by the respondents, there is a difference between immunized and unimmunized children. Their perception is that immunized children are healthier and stronger than those who are not. We observed that some of the participants, while expressing their perception about the importance of vaccination, became emotional. This was ignited by real life experiences that they themselves have had:

“...among my children, one of them did not complete his immunization, and when there is an outbreak, he is the only one among them that suffer a lot. He fall sick with severe fever and headache.”

Perception regarding the seriousness of measles

In particular, caregivers demonstrated high awareness of measles and perceived the disease to be very serious and dangerous. Across all groups, beliefs about the consequences of not getting immunized for measles was strong. They attributed failure to immunize with occurrence and severity of disease.

“...measles is more dangerous if your child is not vaccinated”

Level of satisfaction with immunization services

Overall, about two-third of the caregivers have accessed immunization in the facilities, and they expressed their satisfaction with the services. According to them, health workers in the facilities are “kind” and “humble”, and they conduct education sessions where they discuss the importance of vaccines. Also, they organize clinics such that delays are avoided:

“They treat everybody with utmost care, and they do not take much of our time and I have not observed any wrong doing here”

“No harassment, they attend to us peacefully”

Level of community awareness about immunization

Caregivers believe that awareness about immunization has improved among people in the community. They stated that people are cooperating more with health workers to have their children immunized. They said that in their communities, it is easy to identify the households that do not immunize their children because they are now few in number. One respondent attribute this to increased awareness from government polio campaign programme. Although targeted at polio, this respondent indicated that it is sensitizing people to take other vaccines.

“Most of the people now are exposed because polio vaccination also helps in making people more aware of the importance of vaccination.”

Fear of side effects

Fear of side effects emerged as one of the only factors potentially reducing caregivers’ motivation for immunization. The most commonly cited side effect was fever.

“This vaccination brings fever, but you will be asked to buy paracetamol for the child”

On account of this, caregivers suggested that many fathers usually prevent their children from being vaccinated. This is also compounded by the number of antigens that children are given during immunization visits. Some consider it as “too much”.

“Even if the mother want to take their children to the hospital, their husband will not allow them. Or if you go for the first time the remaining days you will not be allowed to take them. His reason is because of the fever that the child suffers after vaccination”

“Some complain that the vaccines are too much for the child and others complain of the fever that children are suffering after the vaccination”

5.4.3 Capability

This construct comprises participants’ knowledge of the vaccines that their child needs. We found that although participants had some knowledge of the timing required for vaccination, most could not mention all the antigens.

Caregiver knowledge of required vaccines

Only some of the caregivers demonstrated knowledge of some of the vaccines that children need. They were only able to mention a few among what is currently recommended in the national series. The commonly mentioned antigens were BCG, measles vaccines, and polio vaccine.

5.5 Discussion

This study explored the factors that influence MOV from the perspective of caregivers who are attending primary healthcare facilities with children aged 0 – 23 months. Using the COM-B model, the reasons for MOV were categorized into three constructs; capability, opportunity, motivation. Several motivating factors that facilitate uptake of immunization were identified, and they could be harnessed to compliment intervention for reducing MOV.

5.5.1 Strengths and limitations

To the best of our knowledge, this is the first study that employed a theory-based framework to explore reasons for MOV from the perspective of caregivers. Using a theoretical framework

enabled us to view the phenomenon through a behavioral science lens. This allowed us to coherently characterize internal and external behavior patterns that can influence the uptake of immunization and cause MOV among caregivers attending health facilities with children. However, our study has some limitations. The purposive sampling method that we used in selecting participants might limit the generalizability of our results. However, our intention was to explore context-specific factors in the pre-implementation phase of a QI project to inform change ideas. Moreover, since the primary health care facility contexts are similar, especially in the urban area of Kano, we believe that our findings are still relevant for policies and practices across the metropolitan LGAs. It may be possible that the overwhelming positive attitude of the caregivers towards immunization may have been influenced by the presence of the researchers. We foresaw this potential limitation and as a result designed our discussion guide to avoid prompting for specific responses. In addition, we ensured that facility staff were not present during discussions or participated in any way.

5.5.2 Factors responsible for missed opportunities for vaccination in Nassarawa, Kano

Several factors that can influence MOV as identified in this study were used to inform a conceptual framework (as shown in **Figure 5.2**) that mirrors the theoretical framework of the study. We found that facilitators of immunization uptake as well as barriers which can result in MOV coexist and interrelate in a dynamic way. This complexity confirms some of the pathways that were proposed in a previous review (11). Among the identified factors in the conceptual framework, we found five that reflected the theorized TDF domains under the construct; opportunity, in the theoretical framework of the study. Also, six factors fitted the TDF domains under motivation. Under capability, only one factor under the knowledge domain of the TDF was identified.

Opportunity

Even if vaccines are available in a public primary health care facility, its utilization for children can still be influenced by contextual factors that are external to their caregiver, which can be social or environmental. Our discussion with caregivers confirmed previous findings that health workers seldom screen the HBR of children who visit the health facilities for reasons other than

immunization (48). Primary health care facilities provide other child health services such as nutrition and growth monitoring, treatment of minor ailments and diseases, minor surgical services such as circumcision among others, and as such, health workers who attend to these children might solely be focusing on their service areas. If the immunization history of children is not reviewed upon even contact with a health facility by the health worker that is attending to them, there are high chances that some whom are eligible for vaccination might be missed. Furthermore, this study also reported that health workers may refuse immunization services on account of late coming or seeking for services on days that are not scheduled for immunization.

In the context where this study was conducted, gender roles are somewhat strictly defined, and women are placed with the responsibility of taking care of the home (49). This often involves cooking in the morning and completing other house tasks (49). At times, this can result in late clinic visits. As such, if clinics have strict timing for immunization services, some children who would have been brought in late could miss their immunization. Similarly, if immunization is only provided on designated days, the timely immunization of new born babies (delivered at home or health facility) could be compromised thus leading to MOV. In addition, we found that the high level of social control that men have over women in this area could also cause MOV among children. Caregivers reported that without their husband's consent, they still cannot vaccinate their children, even if they're in a health facility for other preventive or curative services.

On the other hand, contextual factors such as free immunization and integration of immunization services into labor rooms were found to be important facilitators. Cost is a recognized barrier to accessing immunization (50, 51). Among parents and caregivers in low income settings, immunization might become an opportunity cost because of many other competing demands (52). Given the public health importance of immunization and its high return on investment, most countries subsidize the services so that it can be provided free of charge (53). This is the current policy in the area where this study was conducted as immunization is provided free of cost. Importantly, we found that caregivers are aware of this social service. This can facilitate uptake. However, the cost of treating vaccine reactions like fever that might occur following immunization are borne for the caregivers, which can result in out-of-pocket expenditure. Several studies have also shown that providing immunization services at other service delivery

points can improve uptake (54-56). In this study, some caregivers indicated that recommended birth doses of vaccines are provided in the labor room as soon as the child is born. This practice saves time and reduces the chance of missed opportunities in this service delivery point.

Motivation

As shown in Figure 2, several factors that enhance caregiver motivation to use immunization services in health facilities were found in this study. Surprisingly, caregivers expressed high perceived burden of vaccine-preventable diseases, especially measles. This seem to have also informed positive perceptions regarding the importance of vaccines. These factors can reduce MOV (16). This is because, high optimism about the value of vaccines and strong beliefs about the consequences of VPDs can inform favorable behavior toward immunization. In addition, caregivers expressed high level of satisfaction with immunization services that are provided in the health facilities.

Although several factors that enhanced motivation were identified, some concerns about side effects were also raised. Experiences with the side effects of vaccines can influence the behavior of caregivers and reduce their motivation to immunize eligible children. This can affect subsequent immunization visits in a child or immunization in that caregiver's subsequent children. Some of the caregivers complained that their children often develop fever after some vaccines are administered. And fear of this fever does result in some caregivers delaying or even refusing other vaccines in the series. Some even raised concerns about the number of vaccines that are administered.

Capability

Other studies have hypothesized that good knowledge of the vaccines that a child needs can reduce MOV (16). In our study, we found that many caregivers still have limited knowledge of the vaccines that are in the national schedule, although caregivers were able to mention several VPDs. As shown in Fig 2, even if the caregiver has knowledge of the diseases, if they don't know the antigens that a child needs, it could still limit their ability to use immunization services in health facilities, thus causing MOV.

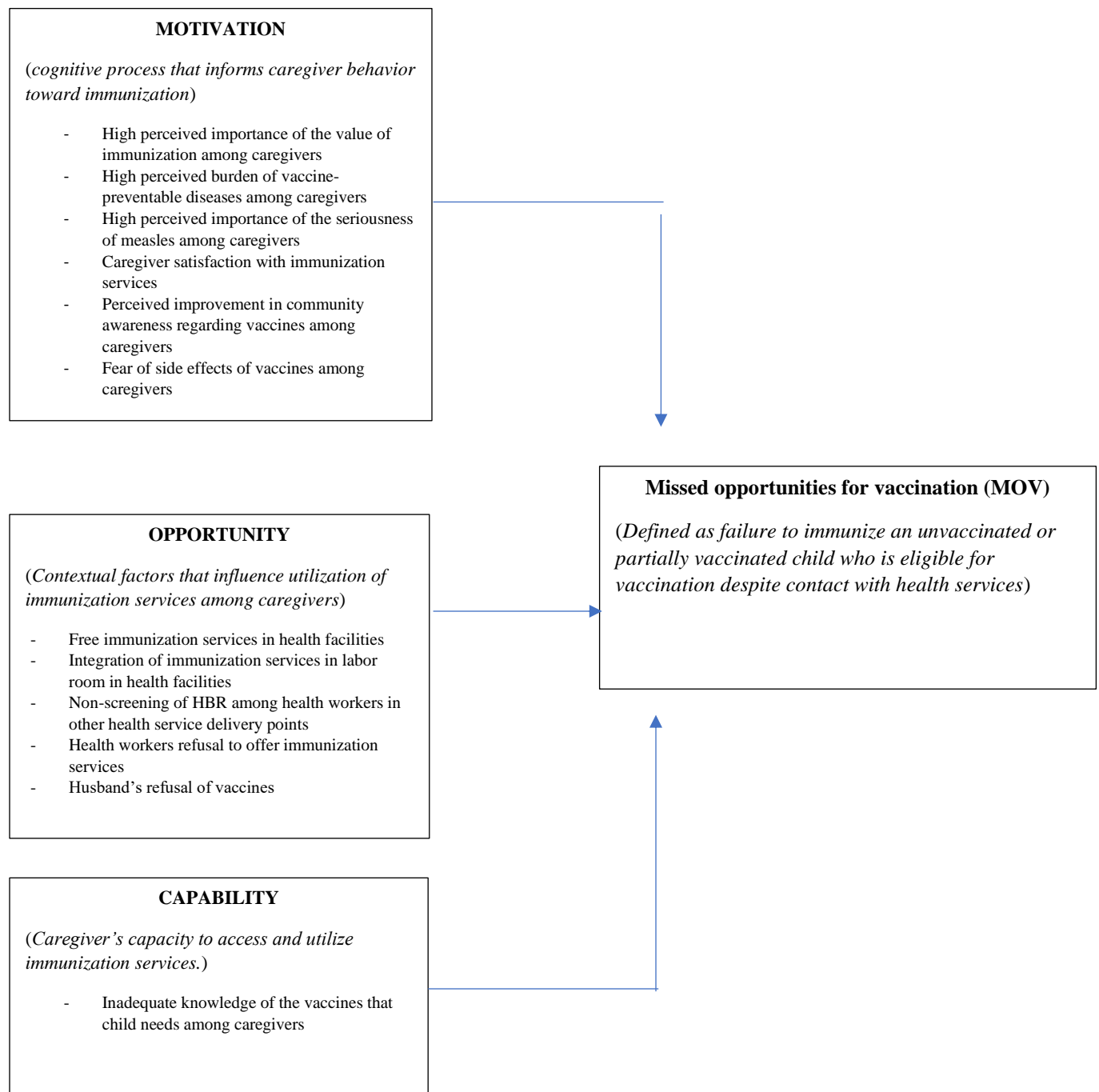


Figure 5.2: A conceptual framework of caregiver-related factors that influence missed opportunities for vaccination among children aged 0 – 23 months attending primary health care facilities in Nassarawa local government area.

5.5.3 Implications for the collaborative quality improvement project

Based on some of the reasons for MOV that were identified in this study, the BCW was used to recommend some change ideas that can be implemented in the QI project. The aim of the QI project is to reduce MOV among children aged 0 – 23 months attending PHC facilities in Nassarawa LGA of Kano. Given scarce resources, low cost ideas that can be considered as “low hanging fruit” should be prioritized. And if properly guided by an implementation framework, they can contribute to closing the “know-do” gap in the immunization sub-system (57). As shown in **Box 5.1**, education, persuasion, training and modelling are recommended intervention functions. To improve screening of HBR and eliminate refusal to offer immunization services due to late coming and scheduling, health workers’ knowledge and understanding of MOV can be increased through educational materials like job aids and programmes like trainings. Also, husbands who prevent their wives from immunizing their children can be persuaded by health workers through proper communication of the benefits of vaccines which can be face-to-face or through phone call. This persuasion can induce positive feeling towards immunization among husbands and lead them to allow their spouses to use immunization services. During clinics, training and retraining sessions for caregivers can be organized to improve their skills of home management of common side effects of childhood vaccines. In addition, model caregivers who are familiar with all the antigens and their timing as specified in the national series can be used as examples for other caregivers to imitate. These interventions can leverage on existing motivational factors among caregivers.

Box 5.1: COM-B Model barriers and recommended intervention functions for a quality improvement project in primary health care facilities in Nassarawa, Kano

	Intervention function								
COM-B Model Component	Education	Persuasion	Incentivization	Coercion	Training	Enablement	Modelling	Environmental restructuring	Restriction
Opportunity									
Motivation									
Capacity									

5.5.4 Implications for broader policies

Our findings are also relevant for immunization policies at local government, and to some extent, state level. The recommended policy categories are shown in **Box 5.2**. To address non-screening of HBR and refusal to offer immunization, the local government health authority in collaboration with the primary health care management board can redesign the service provision plan for all primary health care facilities to integrate HBR screening and provision of immunization services at every service delivery point. In addition, social marketing of the value of immunization that target men in the community can be instituted or strengthened. Furthermore, existing regulations on adverse events following immunization (AEFI) surveillance can be strengthened. Also, a simplified version of the national immunization schedule that contains the timing of each antigen can be translated to the local language and distributed to caregivers. This is in line with the World Health Organization's recommendation on the use of home-based records (HBR) (58). In fact, one of the specified functions of HBR is to facilitate caregiver education (58).

Box 5.2: COM-B Model barriers and recommended policy categories

	Policy Category						
COM-B Model Component	Environmental/Social planning	Communication/Marketing	Legislation	Service provision	Regulation	Fiscal measure	Guidelines
Opportunity							
Motivation							
Capacity							

5.5.5 Implications for future research

This study focused on primary health care facilities in an urban Local Government Area in Kano, Nigeria. However, majority of the LGAs in the state are rural. To influence state-wide immunization policies, it's important to generate data that adequately reflect other contexts. As such, similar studies in rural areas are recommended. To further strengthen the evidence base, it might also be necessary to combine quantitative and qualitative data. In addition, research with male caregivers is advocated.

5.6 Conclusion

This study identified a useful framework that aided deeper insights into caregiver-related factors responsible for MOV in Nassarawa, Kano. It demonstrated how the causes of MOV involve a complex interplay of social and psychological factors, although contextual factors emerged as the most pertinent drivers. Aligning these factors with the COM-B model, we were able to recommend theory-informed interventions and policy recommendations to address MOV. Some of the findings can be used to inform change ideas in a quality improvement programme and should be explored.

5.7 Competing interest

None declared

5.8 Author contribution

The study was conceptualized by AAA. He conducted FGDs, analyzed and interpreted the findings, and developed the first draft of the manuscript. SC contributed to interpretation of findings and revision of manuscript. CSW, OAU, MAG reviewed and approved the study concept, supervised and contributed to analysis and interpretation, and manuscript development. All authors approved the final manuscript.

5.9 References

1. World Health Organization. Standards for improving the quality of care for children and young adolescents in health facilities. Geneva, Switzerland.2018.
2. Maman K, Zöllner Y, Greco D, Duru G, Sendyona S, Remy V. The value of childhood combination vaccines: from beliefs to evidence. *Human vaccines & immunotherapeutics*. 2015;11(9):2132-41.
3. Ehreth J. The global value of vaccination. *Vaccine*. 2003;21(7-8):596-600.
4. World Health Organization. Global Vaccine Action Plan 2011-2020 Geneva, Switzerland: World Health Organization; 2013 [cited 2019 21st April 2019 at 2:00PM]. Available from: https://www.who.int/immunization/global_vaccine_action_plan/GVAP_doc_2011_2020/en/.
5. Adedokun ST, Uthman OA, Adekanmbi VT, Wiysonge CS. Incomplete childhood immunization in Nigeria: a multilevel analysis of individual and contextual factors. *BMC public health*. 2017;17(1):236.
6. Adeloye D, Jacobs W, Amuta AO, Ogundipe O, Mosaku O, Gadanya MA, et al. Coverage and determinants of childhood immunization in Nigeria: A systematic review and meta-analysis. *Vaccine*. 2017;35(22):2871-81.
7. National Primary Healthcare Development Agency and National Bureau of Statistics. Nigeria National Immunization Coverage Survey 2016/17, Final Report. Abuja, Nigeria: National Primary Healthcare Development Agency and National Bureau of Statistics; 2017.
8. Abba B, Abdullahi S, Bawa S, Getso KI, Bello IW, Korir C, et al. Mobilizing political support proved critical to a successful switch from tOPV to bOPV in Kano, Nigeria 2016. *BMC public health*. 2018;18(Suppl 4):1302.
9. World Health Organization. Planning guide to reduce missed opportunities for vaccination. Geneva, Switzerland: World Health Organization; 2017.
10. Hanson CM, Mirza I, Kumapley R, Ogbuanu I, Kezaala R, Nandy R. Enhancing immunization during second year of life by reducing missed opportunities for vaccinations in 46 countries. *Vaccine*. 2018;36(23):3260-8.
11. Adamu AA, Sarki AM, Uthman OA, Wiyeh AB, Gadanya MA, Wiysonge CS. Prevalence and dynamics of missed opportunities for vaccination among children in Africa: applying systems thinking in a systematic review and meta-analysis of observational studies. *Expert Rev Vaccines*. 2019;1-12.
12. Uthman OA, Sambala EZ, Adamu AA, Ndwandwe D, Wiyeh AB, Olukade T, et al. Does it really matter where you live? A multilevel analysis of factors associated with missed opportunities for vaccination in sub-Saharan Africa. *Human vaccines & immunotherapeutics*. 2018;14(10):2397-404.
13. Onyiriuka A. Vaccination default rates among children attending a static immunization clinic in Benin City, Nigeria. 2005.
14. Tagbo B, Onwuasigwe C. Missed immunization opportunitieess among children in Enugu. *Nigerian Journal of Paediatrics*. 2005;32(4):73-6.
15. Ubajaka F, Ukegbu A, Okafor N, Ejiofor O. The prevalence of missed oppor-tunities for immunization among children utilizing immunization services in NNAMDI AZIKIWE University Teaching Hospital, NNEWI. *J Biol Agric Healthc*. 2012;6(2).

16. Favin M, Steinglass R, Fields R, Banerjee K, Sawhney M. Why children are not vaccinated: a review of the grey literature. *International health*. 2012;4(4):229-38.
17. Rainey JJ, Watkins M, Ryman TK, Sandhu P, Bo A, Banerjee K. Reasons related to non-vaccination and under-vaccination of children in low and middle income countries: findings from a systematic review of the published literature, 1999–2009. *Vaccine*. 2011;29(46):8215-21.
18. Velandia-Gonzalez M, Trumbo SP, Diaz-Ortega JL, Bravo-Alcantara P, Danovaro-Holliday MC, Dietz V, et al. Lessons learned from the development of a new methodology to assess missed opportunities for vaccination in Latin America and the Caribbean. *BMC Int Health Hum Rights*. 2015;15(1):5.
19. Bernard HR. *Research methods in anthropology: Qualitative and quantitative approaches*: Rowman & Littlefield; 2017.
20. Creswell JW, Poth CN. *Qualitative inquiry and research design: Choosing among five approaches*: Sage publications; 2017.
21. Pope C, Mays N, Ziebland S, le May A, Williams S, Coombs M, et al. *Qualitative methods in health research. methods*. 2000;1:2.
22. MacFarlane A, O'Reilly-de Brún M. Using a theory-driven conceptual framework in qualitative health research. *Qualitative Health Research*. 2012;22(5):607-18.
23. Cane J, O'Connor D, Michie S. Validation of the theoretical domains framework for use in behaviour change and implementation research. *Implementation science*. 2012;7(1):37.
24. Atkins L, Francis J, Islam R, O'Connor D, Patey A, Ivers N, et al. A guide to using the Theoretical Domains Framework of behaviour change to investigate implementation problems. *Implementation Science*. 2017;12(1):77.
25. Nilsen P. Making sense of implementation theories, models and frameworks. *Implementation science : IS*. 2015;10(1):53.
26. Michie S, van Stralen MM, West R. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implementation science : IS*. 2011;6(1):42.
27. Wandersman A, Alia KA, Cook B, Ramaswamy R. Integrating empowerment evaluation and quality improvement to achieve healthcare improvement outcomes. *BMJ Quality & Safety*. 2015;24(10):645.
28. de Quadros CA. Immunization: an essential component of primary health care. *Chronicles*. 1983;3(1):7-10.
29. Abdulraheem bI, Olapipo A, Amodu M. Primary health care services in Nigeria: Critical issues and strategies for enhancing the use by the rural communities. *Journal of public health and epidemiology*. 2012;4(1):5-13.
30. Alexander KE, Brijnath B, Mazza D. Barriers and enablers to delivery of the Healthy Kids Check: an analysis informed by the Theoretical Domains Framework and COM-B model. *Implementation science : IS*. 2014;9(1):60.
31. French SD, Green SE, O'Connor DA, McKenzie JE, Francis JJ, Michie S, et al. Developing theory-informed behaviour change interventions to implement evidence into practice: a systematic approach using the Theoretical Domains Framework. *Implementation Science*. 2012;7(1):38.
32. Dyson J, Lawton R, Jackson C, Cheater F. Does the use of a theoretical approach tell us more about hand hygiene behaviour? The barriers and levers to hand hygiene. *Journal of Infection Prevention*. 2011;12(1):17-24.

33. Francis JJ, Stockton C, Eccles MP, Johnston M, Cuthbertson BH, Grimshaw JM, et al. Evidence-based selection of theories for designing behaviour change interventions: Using methods based on theoretical construct domains to understand clinicians' blood transfusion behaviour. *British journal of health psychology*. 2009;14(4):625-46.
34. Kredo T, Cooper S, Abrams A, Muller J, Volmink J, Atkins S. Using the behavior change wheel to identify barriers to and potential solutions for primary care clinical guideline use in four provinces in South Africa. *BMC health services research*. 2018;18(1):965.
35. O'Brien BC, Harris IB, Beckman TJ, Reed DA, Cook DA. Standards for reporting qualitative research: a synthesis of recommendations. *Academic Medicine*. 2014;89(9):1245-51.
36. Duncan EAS, Nicol MM. Subtle Realism and Occupational Therapy: An Alternative Approach to Knowledge Generation and Evaluation. *British Journal of Occupational Therapy*. 2016;67(10):453-6.
37. Maconachie R. *Urban Growth and Land Degradation in Developing Cities: Change and Challenges in Kano Nigeria*: Routledge; 2016.
38. Kibon UA, Ahmed M. Distribution of Primary Health Care Facilities in Kano Metropolis Using GIS (Geographic Information System). *Research Journal of Environmental and Earth Sciences*. 2013;5(4):167-76.
39. Makama SD. 2006 National Population and Housing Census. Abuja: National Population Commission, Commission NP; 2010.
40. National Population Commission. Population and housing census of the Federal Republic of Nigeria. Priority tables. 2006;1.
41. Kitzinger J. The methodology of focus groups: the importance of interaction between research participants. *Sociology of health & illness*. 1994;16(1):103-21.
42. Kitzinger J. Qualitative research: introducing focus groups. *Bmj*. 1995;311(7000):299-302.
43. World Health Organization. *Methodology for the Assessment of Missed Opportunities for Vaccination*. Geneva, Switzerland 2017.
44. Saunders B, Sim J, Kingstone T, Baker S, Waterfield J, Bartlam B, et al. Saturation in qualitative research: exploring its conceptualization and operationalization. *Qual Quant*. 2018;52(4):1893-907.
45. van Nes F, Abma T, Jonsson H, Deeg D. Language differences in qualitative research: is meaning lost in translation? *Eur J Ageing*. 2010;7(4):313-6.
46. Brooks J, McCluskey S, Turley E, King N. The utility of template analysis in qualitative psychology research. *Qualitative Research in Psychology*. 2015;12(2):202-22.
47. Sandelowski M. Focus on qualitative methods. The use of quotes in qualitative research. *Research in nursing & health*. 1994;17(6):479-82.
48. Olorunsaiye CZ, Langhamer MS, Wallace AS, Watkins ML. Missed opportunities and barriers for vaccination: a descriptive analysis of private and public health facilities in four African countries. *Pan African Medical Journal*. 2017;27(Suppl 3):6-.
49. Kemi AO, Jenyo OG. Gender Equality and the Empowerment of Women and Girls in Nigeria: The Way Forward to National Security. *Open Journal of Social Sciences*. 2016;4(07):230.
50. Santoli JM, Szilagyi PG, Rodewald LE. Barriers to immunization and missed opportunities. *Pediatric annals*. 1998;27(6):366-74.
51. Lieu TA, McGuire TG, Hinman AR. Overcoming economic barriers to the optimal use of vaccines. *Health Affairs*. 2005;24(3):666-79.

52. Clemens J, Jodar L. Introducing new vaccines into developing countries: obstacles, opportunities and complexities. *Nature medicine*. 2005;11.
53. Ozawa S, Clark S, Portnoy A, Grewal S, Brenzel L, Walker DG. Return on investment from childhood immunization in low-and middle-income countries, 2011–20. *Health Affairs*. 2016;35(2):199-207.
54. Mwaniki MK, Vaid S, Chome IM, Amolo D, Tawfik Y. Improving service uptake and quality of care of integrated maternal health services: the Kenya kwale district improvement collaborative. *BMC health services research*. 2014;14(1):416.
55. Adams WG, Conners WP, Mann AM, Palfrey S. Immunization entry at the point of service improves quality, saves time, and is well-accepted. *Pediatrics*. 2000;106(3):489-92.
56. Bajpai N, Sachs JD, Dholakia RH. Improving access, service delivery and efficiency of the public health system in rural India. 2009.
57. Adamu AA, Adamu AL, Dahiru AI, Uthman OA, Wiysonge CS. Mainstreaming implementation science into immunization systems in the decade of vaccines: A programmatic imperative for the African Region. *Human vaccines & immunotherapeutics*. 2018;14(10):2443-6.
58. World Health Organization. Practical guide for the design, use and promotion of home-based records in immunization programmes Geneva, Switzerland: World Health Organization; 2015 [cited 2019 21st April 2019 at 5:07PM]. Available from: https://www.who.int/immunization/monitoring_surveillance/routine/homebasedrecords/en/.

Chapter 6: Implementation and evaluation of a collaborative quality improvement project to improve immunization rate and reduce missed opportunities for vaccination in primary health care facilities: a time series study in Kano, Nigeria

6.0 About this chapter

In this chapter we report the implementation and evaluation of a quality improvement programme. This chapter has been published by Taylor and Francis Group in *Expert Review of Vaccines* on 25th July 2019 (ahead of print) and can be accessed through the following link: <https://doi.org/10.1080/14760584.2019.1647782>. The citation of this article is as follows: Abdu A Adamu, Olalekan A Uthman, Muktar A Gadanya & Charles S Wiysonge. Implementation and evaluation of a collaborative quality improvement programme to improve immunization rate and reduce missed opportunities for vaccination in primary health care facilities: a time series study in Kano, Nigeria. *Expert Review of Vaccines* (2019). DOI: <https://doi.org/10.1080/14760584.2019.1647782>. Epub 2019 Jul 25.

6.1 Abstract

Introduction: We aimed to implement a quality improvement (QI) collaborative in primary health care (PHC) facilities in Nassarawa Local Government Area of Kano, Nigeria, to reduce missed opportunities for vaccination (MOV) among children aged 0 – 23 months.

Method: Plausibility evaluation design was used in this study. Frontline health workers from five purposively selected PHC facilities used divergent-convergent thinking to select change ideas. Change ideas were implemented in two plan-do-study-act cycles that were four weeks apart. Statistical process control using P-charts were used to plot the outcomes over time. Upper and lower control limits were calculated for each p-chart.

Result: In the facilities that implemented the QI programme, the average percentage of MOV in the pre-implementation period was 31.7% with an Upper Control Limit (UCL) of 44.5% and Lower Control Limit (LCL) of 18.9%. After commencing QI implementation, data points stabilized as all points were within the control limits. Improvement was more evident in PHC 1 and 5.

Conclusion: The findings from this study suggest that frontline health workers are capable of tailoring change ideas to their local context to generate context-specific change ideas. It also showed that QI can be used to attain process control in the occurrence of MOV.

6.2 Introduction

In Nigeria, low routine immunization coverage level has remained an unrelenting problem, partly due to missed opportunities for vaccination (MOV) (1-6). A recent study that explored the dynamics of MOV found that the factors that are responsible for it are complex as interdependent and interrelated caregiver-, health worker-, and the health system-related factors were illustrated using a causal loop diagram (7). Furthermore, most of the factors are related to the dimensions of healthcare quality (7, 8). With the recent interest in redesigning health care systems to simultaneously pursue the triple aim of better patient outcome, improved population health and reduce healthcare cost, the use of quality improvement (QI) in health care settings has become more popular (9, 10). However, existing evidence on the use of QI to address MOV are mainly in the United States, with a dearth of literature from low-and-middle-income countries (11).

QI enables the implementation of multifaceted change ideas (interventions) within complex health systems using iterative processes such as Plan-Do-Study-Act (PDSA) to institute rapid improvement in a health outcome (12-14). Therefore, using QI to address MOV in a low immunization coverage setting like Nigeria can potentially improve the number of children who are protected against vaccine-preventable diseases over a short period of time (1, 15). QI programmes aimed at reducing MOV have employed change ideas such as reminders, prompts, and provider education among others (16). However, these change ideas were implemented in health facilities in a high income setting that have access to automated health informatics systems such as electronic medical records (17, 18). In Nigeria, immunization records are largely paper-based, and health workers rely on the child's home-based records (HBR) or caregiver recall to ascertain immunization history (19). Therefore, such contextual differences as well as broad issues like innovation fit, stakeholder engagement, and buy-in from leadership need to be taken into consideration when planning a QI programme in Nigeria (20). Besides, current literature have suggested that these factors can influence progress towards the desired outcome (13, 21).

Several implementation science frameworks have been proposed to guide the implementation of health interventions so as to maximize implementation quality (22, 23). One of such is the quality implementation framework (QIF) which describes the process of implementation in 14

steps (22). These steps are divided into four phases which include: “initial consideration regarding host setting, creating a structure for implementation, ongoing structure once implementation begins, and improving future application” (22). Nevertheless, this framework overemphasizes the role and significance of the service delivery stakeholders to the overall quality of implementation (22). Another more balanced framework called the Interactive Systems Framework for Dissemination and Implementation (ISF) recognizes other systems apart from those responsible for service delivery (23). This framework suggests that synthesis and translation system, support system and delivery systems all work together to ensure quality implementation (23).

In this study, we implemented a collaborative QI programme in primary health care (PHC) facilities in Nassarawa Local Government Area (LGA) of Kano State, Nigeria, with the goal of improving immunization rate and reducing MOV. The change package was co-designed with frontline providers and implemented by them. ISF was used to guide its implementation (23). To further enhance the probability of program success, these health workers were also empowered to monitor the performance of the QI intervention by themselves (24). Furthermore, robust stakeholder inclusion, participation and capacity building was conducted (20). Since QI involves introducing process change, statistical process control was used for the analysis to enable the identification of random variation and special cause variation (25, 26).

The objective of the study was to implement and evaluate a quality improvement programme for addressing missed opportunities for vaccination among children aged 0 – 23 months attending primary health care facilities in Nassarawa, Kano, Nigeria.

6.3 Methods

This study was reported in line with the Standards for Quality Improvement Reporting Excellence version 2.0 (SQUIRE 2.0) (27).

6.3.1 Context

To ensure that healthcare is available at the grassroots, primary health care (PHC) was adopted as the cornerstone of Nigeria's health system (28). This level of health care has provision of routine immunization services as one of its main functions. PHC is primarily delivered through PHC facilities which are categorized as PHC centre, PHC clinic and health post. The highest level is a PHC centre which is directly managed by the local government authority and is expected to serve the entire ward. This is followed by a PHC clinic which can be managed by the local government authority or ward development committee and is expected to serve a neighborhood of about 2500 to 5000 people. Then a health post is managed by the village development committee and is expected to serve a village of about 500 people. In Kano, just like other Nigerian states, PHC facilities provide routine immunization services according to the national schedule (29). The Kano State Primary Health Care Management Board (KSPHCMB) is responsible for coordinating these PHCs including all immunization activities. In Nassarawa LGA, the PHC department is headed by a PHC coordinator (PHCC). This coordinator is supported by four assistant PHC coordinators (APHCC). One of these APHCC is the local government immunization officer (LIO). Each PHC facility is headed by an "in-charge" who is responsible for day-to-day management. All service delivery points in the facilities have appoint heads. Since routine immunization (RI) is a key activity in these facilities, RI focal persons are assigned.

Within the PHC facilities in Nassarawa LGA, quantitative and qualitative interviews with caregivers of children aged 0 – 23 months before implementation of the QI interventions enabled the identification of some factors that may be responsible for MOV in the setting. They include non-screening of the HBR of children attending clinics, failure to receive vaccination on the day of clinic visit, refusal to offer immunization services by health workers, husband's refusal to immunize child, and fear of vaccine side effects among others.

6.3.2 Implementation of the quality improvement programme

Initial planning

At state level (Executive Secretary of Kano State PHCMB, state immunization officer (SIO), and Nassarawa Zonal Director of the PHCMB) and LGA level (PHCC and LIO) stakeholders were engaged through letter notification and face-to-face planning meetings to obtain their buy-in, solicit full participation and develop a common understanding of responsibilities. Together with the PHCC and LIO, five facilities were identified for implementation of the QI interventions. According to the stakeholders, these facilities have the requisite human resources to support implementation.

Choosing change ideas

Through the LGA PHC department, facility QI teams were created and team members from each PHC facility were invited to participate in a workshop on MOV and QI. Each facility-based QI team comprised of facility in-charge, facility secretary, immunization focal person, maternity focal person, and out-patient-department (OPD) focal person. During the workshop, the teams were exposed to existing evidence-based interventions that can reduce MOV (30). PowerPoint presentations were used to deliver the topics. Also, several change ideas (QI interventions) targeting providers, clients and health systems that were synthesized in a scoping review for the project were also discussed (16). Then divergent-convergent thinking was used to generate context-specific change ideas that were informed by the local experience of the health workers to ensure ‘innovation fit’. First, sticky notes were given to each participant to quietly and individually write down as many change ideas as possible that can address MOV. This was ensued by team deliberation on the selected change ideas and its potential ease of applicability in PHCs in Nassarawa LGA. During the team level brainstorming session, key findings from data collected during the baseline period were discussed and participants agreed to prioritize efforts that can improve screening of HBR. After team discussion, the identified change ideas were placed on cardboards. Then all participants from the five teams selected the most feasible ideas through voting and open discussion. The choice of change ideas was based on a judgement that an intervention would not increase health worker workload significantly. It should be simple,

require low effort to implement and can potentially yield high impact. Furthermore, change ideas should be “low cost” and easy to integrate into current system in the PHC facilities.

The final set of change ideas that were agreed upon were grouped into three categories based on their broad functions. They included: error proofing (placing reminder tags on patient cards), change work environment (placing posters and charts with information about MOV prominently in the facilities and consulting room, conducting daily routine immunization, procuring additional cold boxes to facilitate immunization at other service delivery points), and health worker-husband interface (initiate phone conversation with fathers of children that refuse vaccines). State and LGA stakeholders that were present during the workshop agreed with the selected change ideas.

Table 6.1: Change ideas implemented in primary health care facilities in Nassarawa, Kano to address MOV

S/No	Change idea	Key problem targeted
1	placing reminder tags on patient cards	Non-screening of home-based records
2	placing posters and charts with information about MOV prominently in the facilities and consulting room, conducting daily routine immunization, procuring additional cold boxes to facilitate immunization at other service delivery points	Health workers refusal to offer immunization
3	initiate phone conversation with fathers of children that refuse vaccines to persuade them.	Husband refusal due to socio-cultural beliefs about immunization

Plan-Do-Study-Act (PDSA) Cycles

The facility-based QI teams led the implementation of the selected change ideas in their respective PHC facilities using Plan-Do-Study-Act (PDSA) cycles (31). The QI aim was ‘to reduce the proportion of MOV among children aged 0 – 23 months attending PHC facilities in Nassarawa LGA’. PDSA 1 started on 3rd January 2019. During this cycle, immunization reminder tags were attached to the patient cards of all clinic attendees with children. The tags measure about 3 centimeters x 1.2 centimeters and were attached to the patient card with a clip. These reminder tags (or immunization reminder tags) prompted health workers to screen the immunization history of all children aged 0 – 23 months that they come in contact with using their HBR or any temporary vaccination document. Then MOV posters and charts were placed in clinics and consultation rooms. Two posters were developed. On one poster, the definition of MOV and how it occurs was described. This was to educate health workers on MOV. On the second one, an algorithm that specifies what health workers can do to reduce MOV was illustrated. This stressed the importance of sending the child to the routine immunization focal person immediately to receive the required antigen. Posters were in English language. Immunization service delivery schedule was modified in the facilities to ensure daily immunization. Also, when a health worker comes in contact with a caregiver whose husband had refused their child to be immunized for socio-cultural reasons, a phone communication was initiated to persuade and educate them. The second iteration commenced on 31st January 2019 (four weeks after PDSA 1). During this cycle, all activities of PDSA 1 were sustained, but additional cold boxes were distributed to the facilities to strengthen the integration of immunization services. QI teams monitored performance by themselves using run charts.

Implementation strategies

To ensure that these change ideas were executed as planned, and consistently, the interactive systems framework (ISF) was adopted to actively guide their implementation (23). Based on the systems of the framework, implementation strategies were created. For each system, a conceptual framework was developed to illustrate linkages and explicate how the implementation strategies functioned (32).

Synthesis and translation system

As shown in **Figure 6.1**, this system represented all activities on synthesizing and disseminating information about QI, MOV and evidence-based interventions for reducing MOV to key stakeholders.

Training state and LGA stakeholders, and facility managers on MOV and QI

A one-day training on MOV and QI was conducted for all stakeholders (state and LGA) including facility-based QI teams to build their knowledge of MOV and introduce them to QI methodology. QI materials were based on the Institute for Healthcare Improvement (IHI) model for improvement (MFI) (33). The MOV materials were based on WHO's MOV planning guide and updated methodology (34, 35).

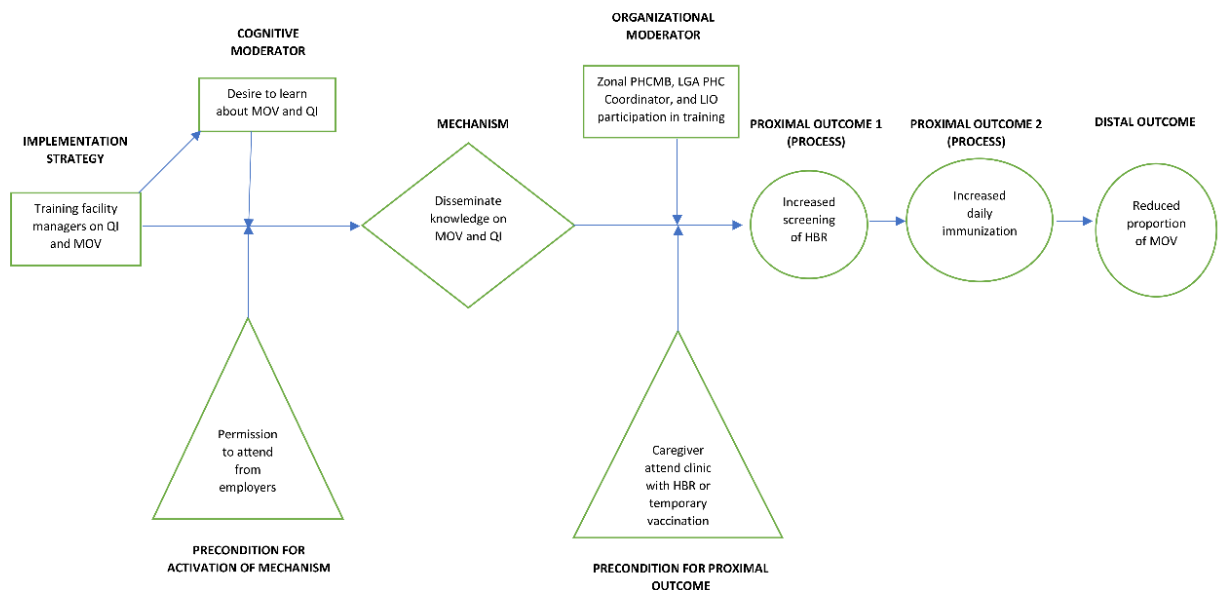


Figure 6.1: Causal link pathway for synthesis and translation system implementation strategies in a collaborative quality improvement project to reduce missed opportunities for vaccination

Support system

As shown in **Figure 6.2**, this system represented all activities that strengthened the capacity of QI teams and other health workers in the facilities to implement the change ideas. They include weekly facility-based QI meeting, peer-to-peer coaching by facility in-charges, and weekly monitoring and supervision visits by state and LGA stakeholders.

Weekly facility-based QI meeting

All the health care workers together with the QI team conduct weekly meetings (every Thursday) in the afternoon such that it does not interfere with work. During the meetings, the QI team reminded all staff about MOV and the change ideas being implemented.

Peer-to-peer coaching

To foster collaboration among QI teams, a peer coaching plan was used. On a weekly basis, one QI team member (usually the in-charge) from one facility is asked to visit another facility to mentor health workers implementing change ideas and ensure that implementation is similar across facilities.

Monitoring and supervision visits

Stakeholders from the KSPHCMB and LGA PHC department conducted weekly monitoring and supervision visits to facilities implementing change ideas. Each stakeholder had an assigned facility which they backstopped.

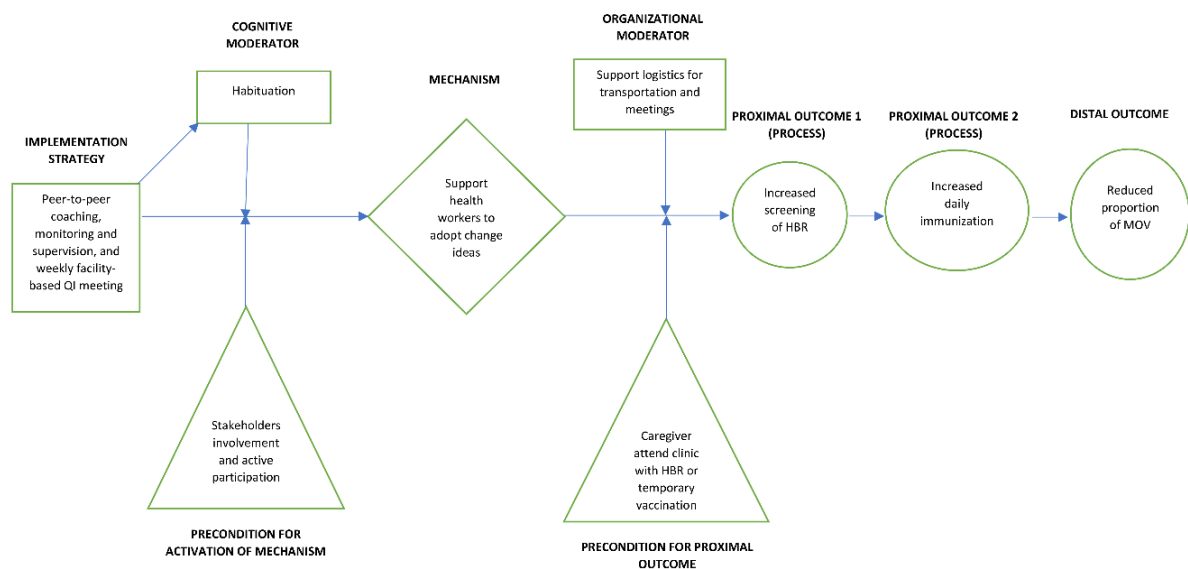


Figure 6.2: Causal link pathway for support system implementation strategies in a collaborative quality improvement project to reduce missed opportunities for vaccination

Delivery system

As shown in **Figure 6.3**, this system encompassed activities that facilitated adoption and integration of the change ideas into routine practice among health workers in the health facilities. They include step down training on MOV and QI and reinforcement HBR screening through spot checks by QI team members.

Step-down training on MOV and QI

Facility QI teams conducted step-down training on QI and MOV with all health workers in the facility. The trainings were conducted in the afternoon so that it would not interrupt service provision.

Facility spot checks to reinforce HBR screening

Facility QI teams developed a reinforcement plan. On a rotational basis, team members conducted spot checks in various consultation rooms and service delivery points to ensure that the immunization reminder tags were attached to patient cards and observe if health workers were asking about immunization history and checking HBR.

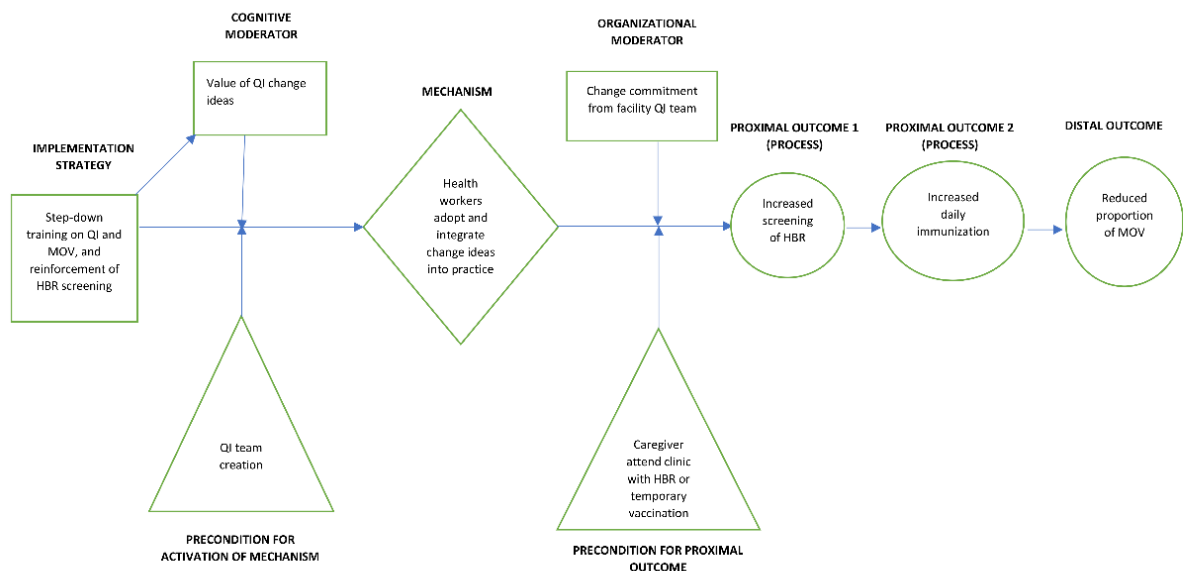
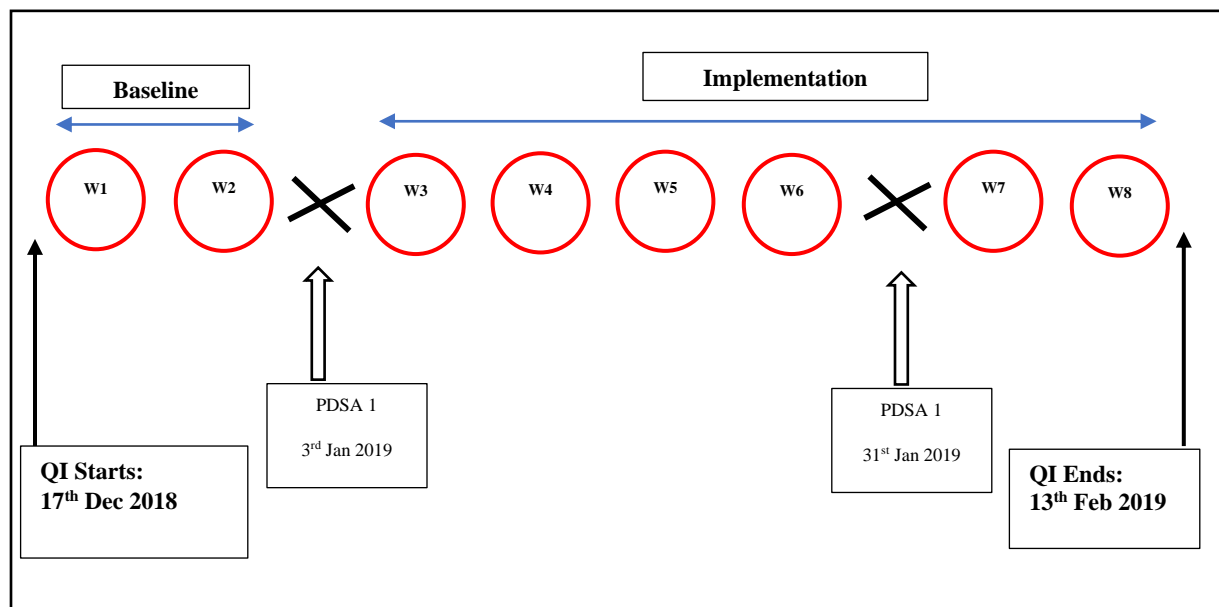


Figure 6.3: Causal link pathway for delivery system implementation strategies in a collaborative quality improvement project to reduce missed opportunities for vaccination

6.3.3 Study of the intervention

Study design

A plausibility evaluation design was used in this study (36). This evaluation design is useful for demonstrating that a programme had an effect that is above and beyond other external influences (36). A 40-day time series with the first 10 days representing the pre-implementation (baseline) period and the remaining 30 days representing the implementation period was used. As shown in **Figure 6.4**, the QI programme began on 17th December 2018, with the establishment of baseline data in week one and two. Then the first PDSA commenced on 3rd January 2019. After four weeks, another PDSA cycle began. Data was collected for two more weeks before the QI programme ended. Each week represented five days as weekends (Saturdays and Sundays) were not included. Also, public holidays within the period were not included.



*W = week; each week represents five days.

*QI = Quality Improvement

*PDSA = Plan-Do-Study-Act

Figure 6.4: Illustration of the study design

Study area

The study was conducted in Nassarawa LGA which is one of the metropolitan LGAs in Kano. According to the 2006 National Housing and Population Census, its population was estimated to

be 596,669 with annual growth rate of 3.3% (37, 38). The 2018 projected population is 880,922. Based on this projection, an estimated 35,236 children are under one year of age and 176, 184 are under five years of age.

Study population

Children aged 0 – 23 months who attended primary health care facilities in Nassarawa LGA were included in the study. Only children who had their HBR or other temporary vaccination documents and were brought to the health facility by a caregiver aged 18 years and above were considered. When a caregiver came to the facility with more than one child, only the youngest child was included.

Sampling

Out of the 18 primary health care facilities that provide immunization services in Nassarawa LGA, 10 were randomly selected from an exhaustive and mutually exclusive list of facilities obtained from the LGA PHC department. Following discussions with stakeholders, five of these PHC facilities were purposively selected to implement the QI programme. Purposive selection of facilities was informed by the availability of adequate human resources. In addition, high paediatric patient turnover and below average performance of immunization services in the facilities were also considered.

Data collection

Semi-structured questionnaire (attached as **Appendix 1**) were used to collect data by trained data collectors. This questionnaire was based on WHO's caregiver tool for MOV assessment which had already being pilot tested (32, 33). But to ensure clarity and suitability of the questions within the study context, the questionnaire was still pretested in two LGAs that are different from our study area. Data was collected through face-to-face health facility exit interviews with caregivers of children aged 0 – 23 months. After collecting sociodemographic data from the caregiver, the child's immunization records was extracted from their HBR or any temporary vaccination document. Data entry was performed using Research Electronic Data Capture (REDCap) mobile app on tablets (37). Also, REDCap was used to manage the data (38). Data collection began 17th December 2018 and ended 13th February 2019.

6.3.4 Measures and Variables

Individual sociodemographic variables included: child age group, child sex, reason for visit, caregiver age group, caregiver sex, marital status, and level of education. PHC facility contextual variables included: facility type, location characteristics, and number of children in attendance.

The outcome measures and their definitions were as follows:

Proportion of MOV for one or more antigens per day: This is the number of children aged 0 – 23 months who remained unvaccinated or partially-vaccinated despite contact with PHC in Nassarawa LGA per day divided by total number of children aged 0 – 23 months who visited the facility per day.

Proportion of MOV for specific antigens per day: This is the number of children aged 0 – 23 months who remained unvaccinated for specific antigens in the national schedule despite contact with PHC facilities in Nassarawa LGA per day divided by total number of children aged 0 – 23 months who visited the facility per day.

The process measures and their definitions were as follows:

Proportion of children whose HBR were screened during visit: This is the number of children aged 0 – 23 months whose HBR were screened by a health worker in PHC facilities in Nassarawa LGA per day divided by total number of children aged 0 – 23 months who visited the facility per day.

Proportion of children who were immunized per day: This is the number of children aged 0 – 23 months who received immunization in PHC facilities in Nassarawa LGA per day divided by total number of children aged 0 – 23 months who visited the facility per day.

The balancing measure and its definition was as follows:

Number of antenatal attendees: This is the number of women who attended ante-natal care per day in PHC facilities in Nassarawa per day.

6.3.5 Analysis

The frequencies and percentages of sociodemographic characteristics of children and their caregivers such as child age group, child sex, reason for facility visit, caregiver age group, caregiver sex, marital status, and level of education were calculated for the pre-implementation and implementation period for both facilities that implemented QI and facilities that did not implement QI.

To summarize the cumulative proportion of MOV for all five facilities that implemented QI per day, the summed total number of children who missed one or more antigens per day was divided by the summed total number of children per day. Similar calculation was also done for the five facilities that did not implement QI. Proportion of child HBR screened per day and proportion of children immunized per day were calculated cumulatively for facilities that implemented QI and facilities that did not implement QI. Each day represented a data point.

Statistical process control using p-charts was then plotted for each process and outcome measure to identify shifts, patterns or trends within the measures following implementation of QI (41). These p-charts demonstrated the variations in each of the measures over time and showed progress toward desired aim (41). P-charts of percentage of MOV for one or more antigen were plotted for each of the five facilities that implemented QI. Then, MOV for specific antigens in these facilities were plotted. To test for special cause variations, upper and low control limits were placed at three standard deviations (3-sigma limit) from the central line (41). The center line in each plot was the mean proportion of the measure in the baseline period.

To statistically demonstrate the effect of the QI programme over time in the facilities that showed obvious evidence of improvement, interrupted time series analysis was performed. The changes in proportion of MOV following implementation of change ideas was estimated by controlling for pre-implementation (baseline) trend and other seasonal effects in each of the facilities. It is based on the assumption that without the change ideas in this QI programme, the pre-implementation trend will continue and remain the same throughout the time period and no factors are affecting the trend (42). First, standard ordinary least square regression models with time series specification (intercept, trend, level change and trend change) were fitted for each facility. Trend is the slope in the pre-implementation period for proportion of MOV (42). Level

change is the change in level of the proportion of MOV that can be attributed to the change ideas between the day before implementation of the first PDSA cycle and the day after implementation (42). Trend change is the difference between the slopes in the pre-implementation period and implementation period (42). The fitted models were then assessed for autoregressive and moving average autocorrelation using the Durbin-Watson test. Also, autocorrelation function (ACF) and partial autocorrelation function (PACF) were plotted. Autocorrelation refers to the correlation between the error terms of adjacent observation (data points of proportion of MOV). Existence of autocorrelation can lead to misleading estimates. After determining the autocorrelation structure, generalized least square regression models were then fitted using the maximum likelihood method. Model diagnostics was performed using likelihood ratio test. Significance test was two-tailed and statistical significance was set at alpha level of less than 0.05. Analysis was performed in Stata 14.2 and R (version 3.5.2) through RStudio's integrated development environment. The R packages used for this analysis included *qicharts2*, *nlme*, and *car* (43-45).

6.3.6 Ethical approval

Ethical clearance for this study (with reference number: S18/02/044) was obtained from Stellenbosch University Health Research Ethics Committee, Kano State Ministry of Health (with reference number: MOH/Off/797/T.I/374) and Aminu Kano Teaching Hospital (with reference number: NHREC/21/08/2008/AKTH/EC/2296) attached as **Appendix 5, 6 and 7** respectively. Information sheet was read to respondents and written informed consent was obtained. The study participants were informed that they could choose not to answer any question or leave the study at any time. No identifiers were collected to ensure anonymity.

6.4 Results

6.4.1 Individual and contextual characteristics

Out of the ten PHC facilities, four are located in non-slum areas and three are primary health care clinics. The number of children with HBR or temporary vaccination document that visited these facilities during the study period vary widely. PHC 2 had only 372 children, while PHC 3 had

1033. PHC 1, PHC 3, PHC 5, PHC 9 and PHC 10 implemented the QI program. Other contextual characteristics are shown on **Table 6.1**.

Table 6.1: Characteristics of primary health care facilities in Nassarawa Local Government

Health Facility	Intervention	Facility Type	Location characteristics	Number of children
PHC 1	QI programme	Primary health centre	Non slum area	866
PHC 2	No QI programme	Primary health clinic	Slum area	372
PHC 3	QI programme	Primary health centre	Non slum area	1033
PHC 4	No QI programme	Primary health clinic	Non slum area	386
PHC 5	QI programme	Primary health centre	Slum area	716
PHC 6	No QI programme	Primary health clinic	Slum area	400
PHC 7	QI programme	Primary health centre	Slum area	951
PHC 8	No QI programme	Primary health centre	Slum area	650
PHC 9	QI programme	Primary health centre	Slum area	695
PHC 10	QI programme	Primary health centre	Non slum area	990

PHC = primary health care; QI = Quality improvement

Facilities that implemented QI were visited by higher number of children than those that did not implement QI in both the pre-implementation period and implementation period. Majority of the children were aged 0 – 11 months. In facilities that implemented QI, about 93.66% of children where aged 0 – 11 months in the pre-implementation period, and 97.09% were also within the same age group in the implementation period. Majority of children visited the health facilities for vaccination. Most of the caregivers of these children had completed secondary education. Other sociodemographic characteristics of children and their caregivers in the pre-implementation and implementation period for all facilities as shown on **Table 6.2**.

Table 6.2: Sociodemographic characteristics of children aged 0 – 23 months and their caregivers that attended primary health care facilities in Nassarawa LGA, Kano State

Variables	Facilities implementing QI		Facilities not implementing QI	
	Pre-implementation period	Implementation period	Pre-implementation period	Implementation period
	n(%)	n(%)	n(%)	n(%)
Child age group				
0 - 11 months	871(93.66)	3271 (97.09)	545 (90.68)	2068 (95.83)
12 - 23 months	59 (6.34)	98 (2.91)	56 (9.32)	90 (4.17)
Child sex				
Male	481(51.83)	1727 (51.35)	311 (51.92)	1204 (55.79)
Female	447(48.17)	1636 (48.65)	288 (48.08)	954 (44.21)
Reason for visit				
Medical consultation and hospitalization	212 (22.82)	427 (12.67)	97 (16.17)	137 (6.35)
Vaccination	541 (58.23)	2486 (73.77)	438 (73.00)	1874 (86.84)
Accompanying caregiver	106 (11.41)	298 (8.84)	30 (5.00)	73 (3.38)
Newborn, growth and development check-up	70 (7.53)	159 (4.72)	35 (5.83)	74 (3.43)
Caregiver age group				
18 - 24 years	322 (34.62)	1269 (37.66)	251 (41.76)	772 (35.77)
25 - 31 years	443 (47.63)	1639 (48.64)	232 (38.60)	957 (44.35)
32 years and above	165 (17.74)	462 (13.71)	118 (19.63)	429 (19.88)
Caregiver sex				
Male	17 (1.83)	32 (0.95)	17 (2.84)	9 (0.42)
Female	913 (98.17)	3337 (99.05)	582 (97.16)	2147 (99.58)
Marital status				
Married	913 (98.17)	3329 (98.78)	575 (95.67)	2123 (98.42)
Unmarried	17 (1.83)	41 (1.22)	26 (4.33)	34 (1.58)
Level of education				
No formal education or didn't complete primary school	115 (12.37)	385 (11.42)	120 (19.97)	453 (21.00)
Completed primary school	94 (10.11)	287 (8.52)	116 (19.30)	318 (14.74)
Completed secondary school	599 (64.41)	2090 (62.02)	313 (52.08)	1263 (58.55)
Post secondary education	122 (13.12)	608 (18.04)	52 (8.65)	123 (5.70)

6.4.2 Statistical process control for process, outcome and balancing measures

Process measures

In **Figure 6.4**, the p-charts shows the percentage of children whose HBR were screened by healthcare workers during visit per day. In the facilities that implemented QI, the average percentage of children screened per day before implementation was 77.2%, with an upper control limit (UCL) of 88.7% and lower control limit (LCL) of 65.7%. In the implementation period, a shift is evident as a run of 15 consecutive data points were above the center line.

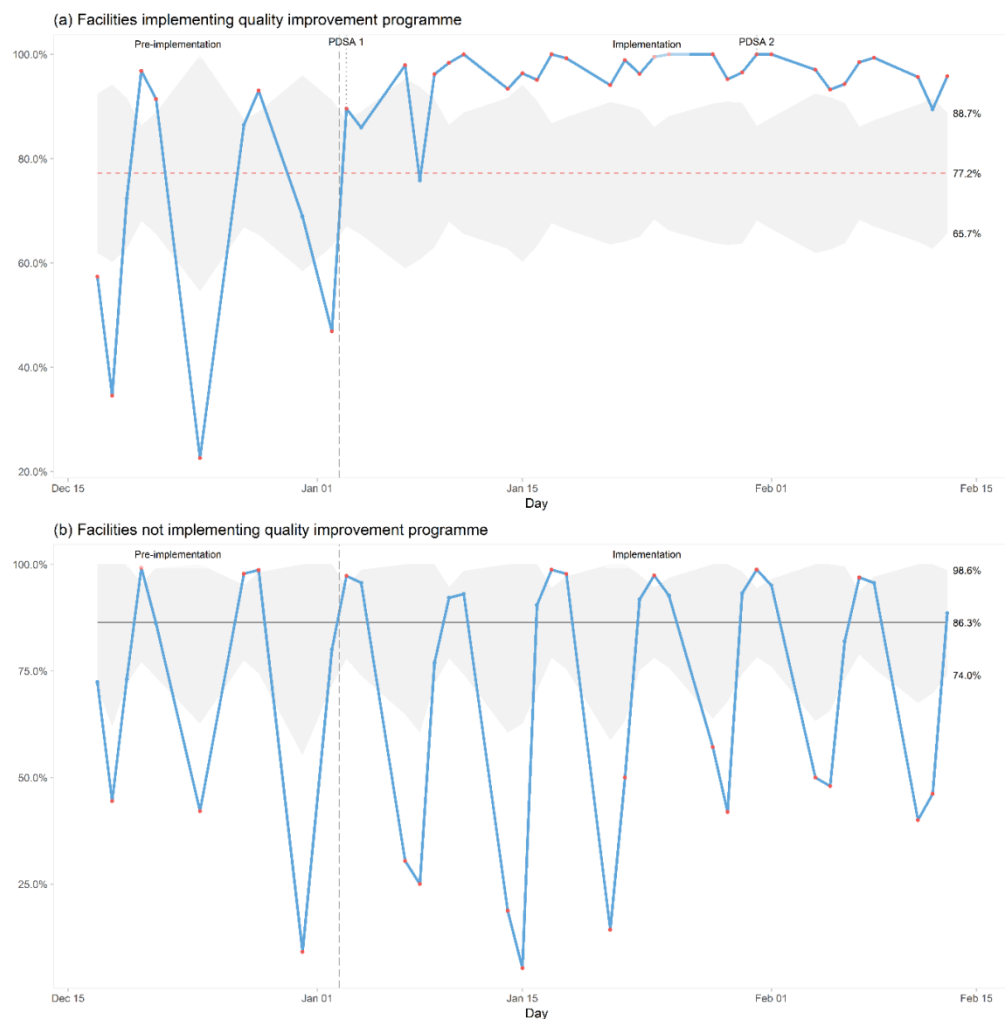


Figure 6.4: Screening of child's home-based records for immunization history in primary health care facilities in Nassarawa LGA, Kano.

In **Figure 6.5**, the p-chart shows the percentage of children who received immunization per day. In facilities that implemented QI, the average percentage of children who received immunization in the pre-implementation period was 61.5% with an UCL of 74.9% and LCL of 48.1%. After commencement of QI, special cause variations were noticed periodically on some days. Most of the data points after the 19th day were above the center line.

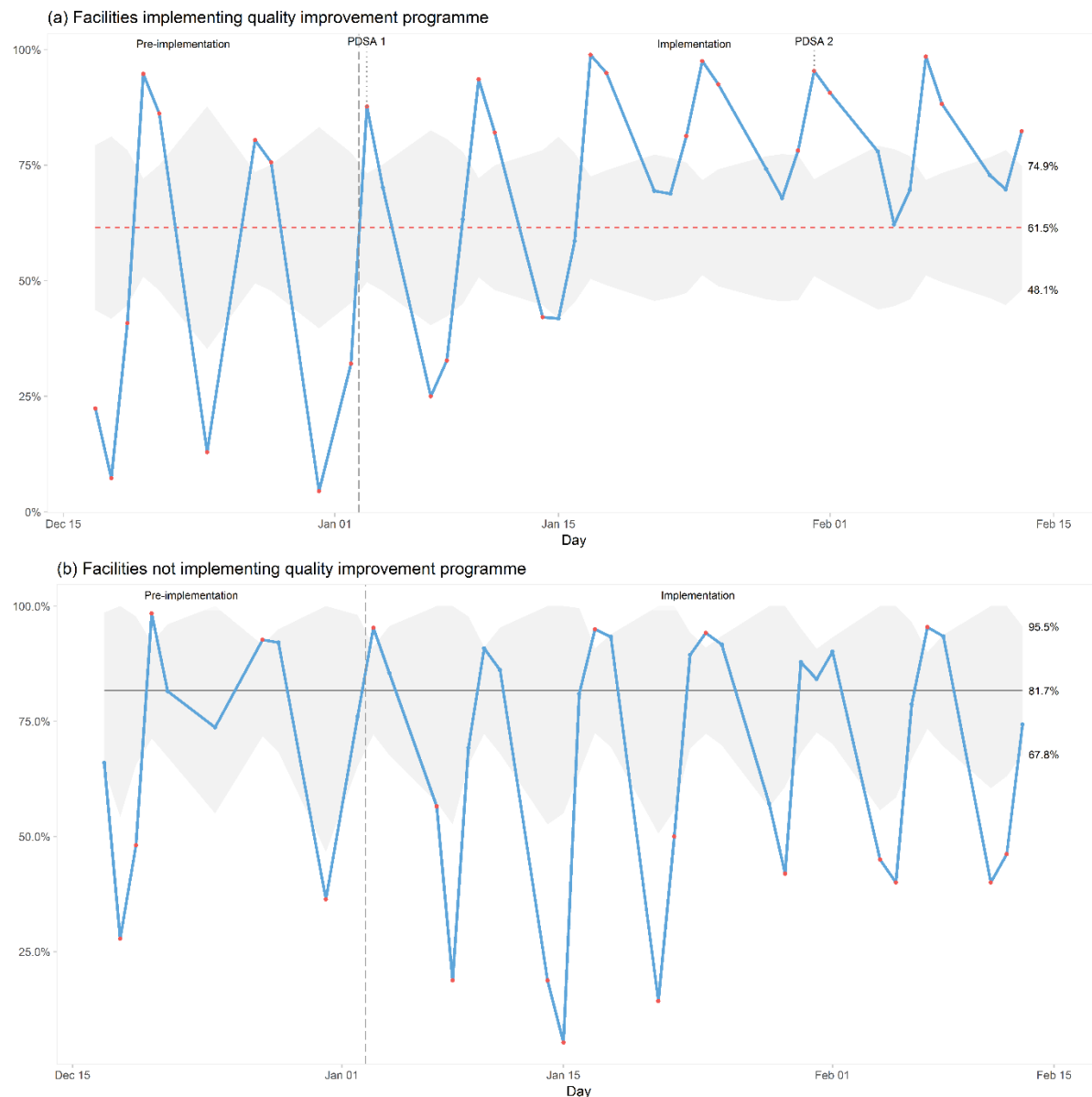


Figure 6.5: Daily immunization of children attending primary healthcare facilities in Nassarawa LGA, Kano

Outcome measure

Figure 6.6 shows the percentage of MOV among children who made contact with the PHC facilities. In the facilities that implemented QI, the average percentage of MOV in the pre-implementation period was 31.7% with an UCL of 44.5% and LCL of 18.9%. During this period, two astronomical points were seen. However, following commencement of QI, all data points stabilized and remained within the control limits. About 10 data points went below the center line and 1 remained on the line. **Figure 6.7 and 6.8**, shows the percentage of MOV among children who made contact with each facility that implemented the QI programme. In PHC 5, 23 data points were below the center line, while in PHC 1, 24 points were below the line. In this PHC, 10 data points crossed the LCL. **Supplementary material 6.1 – 6.5** shows the p-chart of MOV for individual antigens.

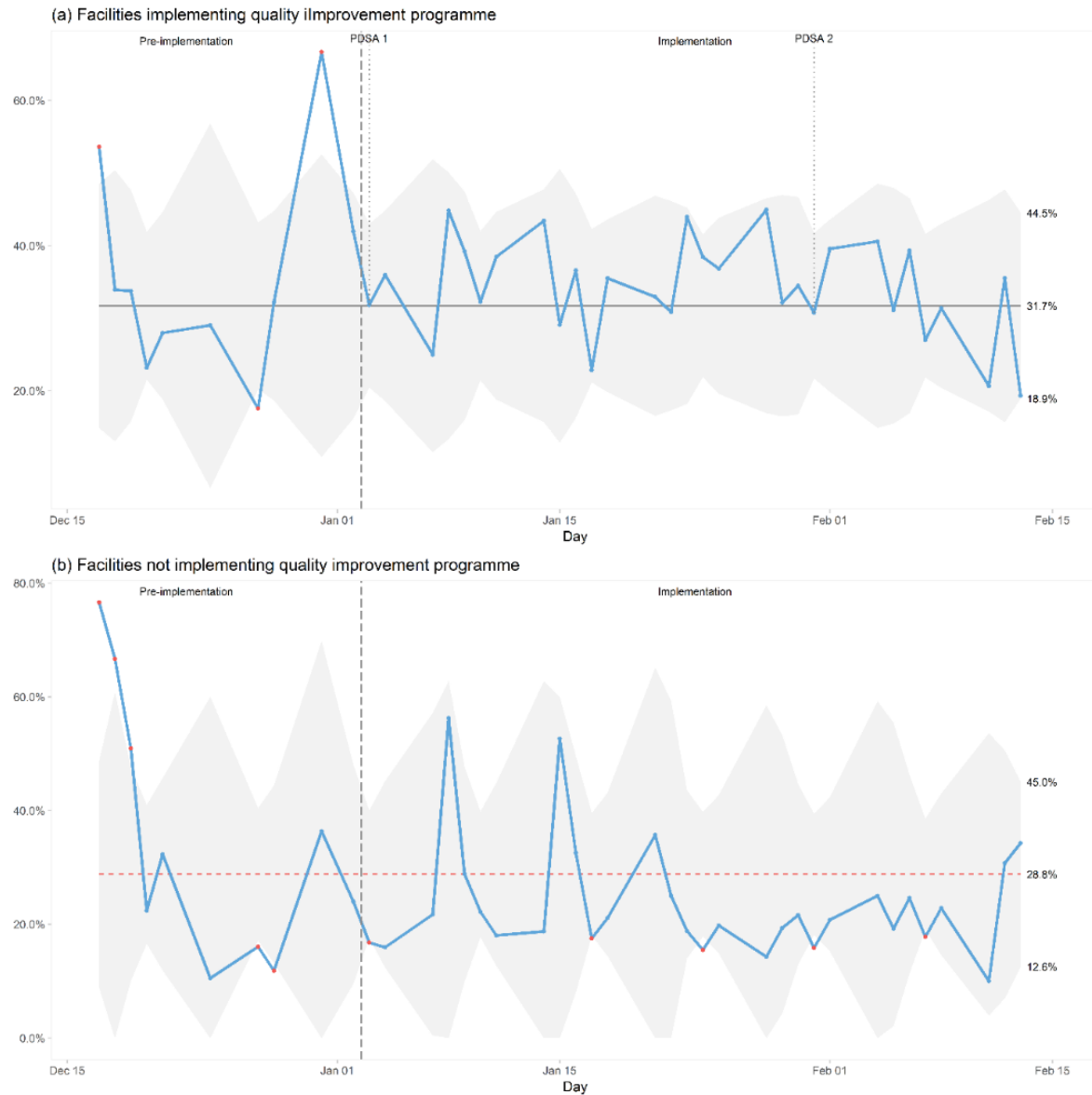


Figure 6.6: Missed opportunities for vaccination in primary health care facilities in Nassarawa LGA, Kano

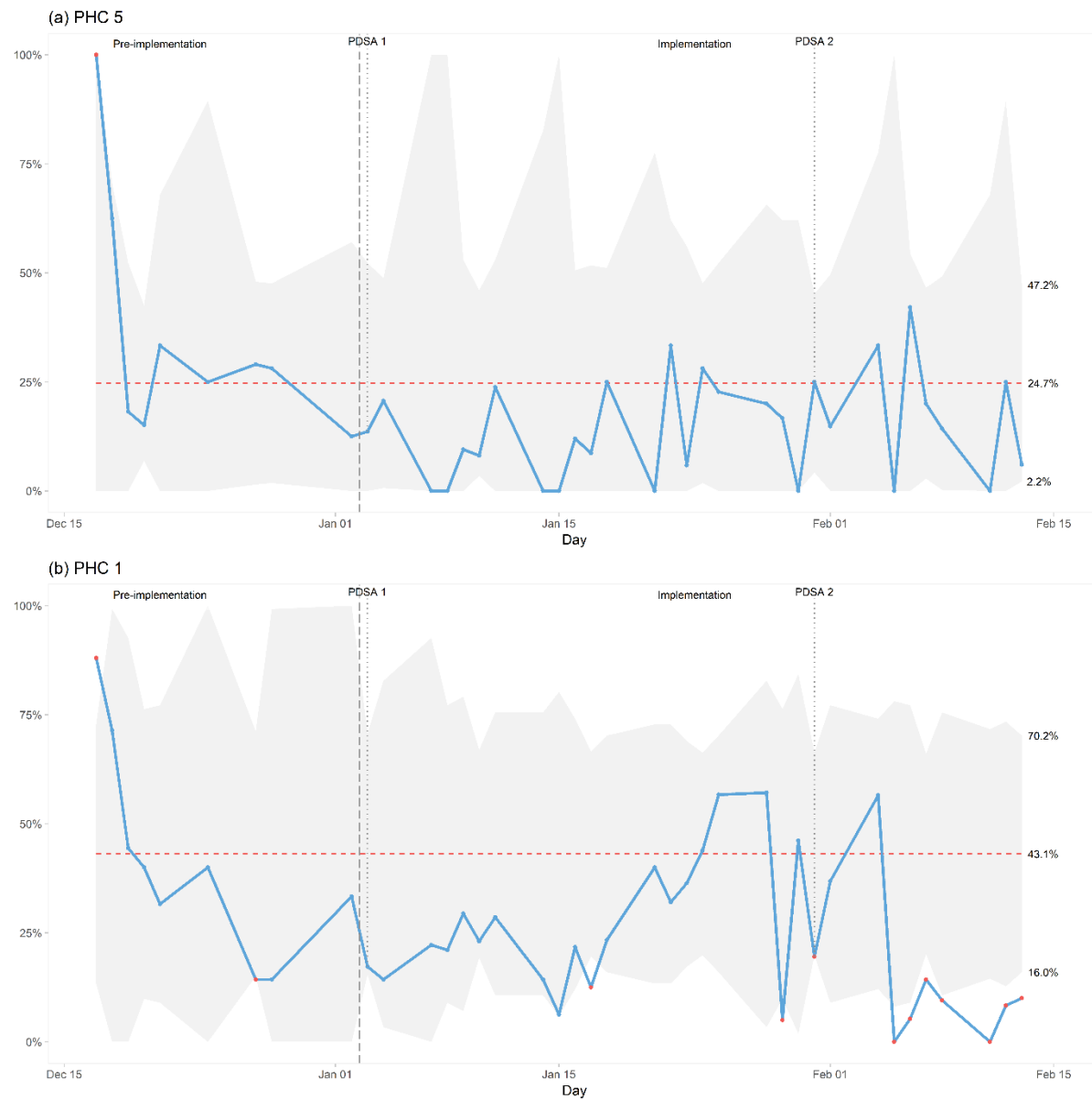


Figure 6.7: Missed opportunities for vaccination in primary health care facility 5 and 1 in Nassarawa LGA, Kano

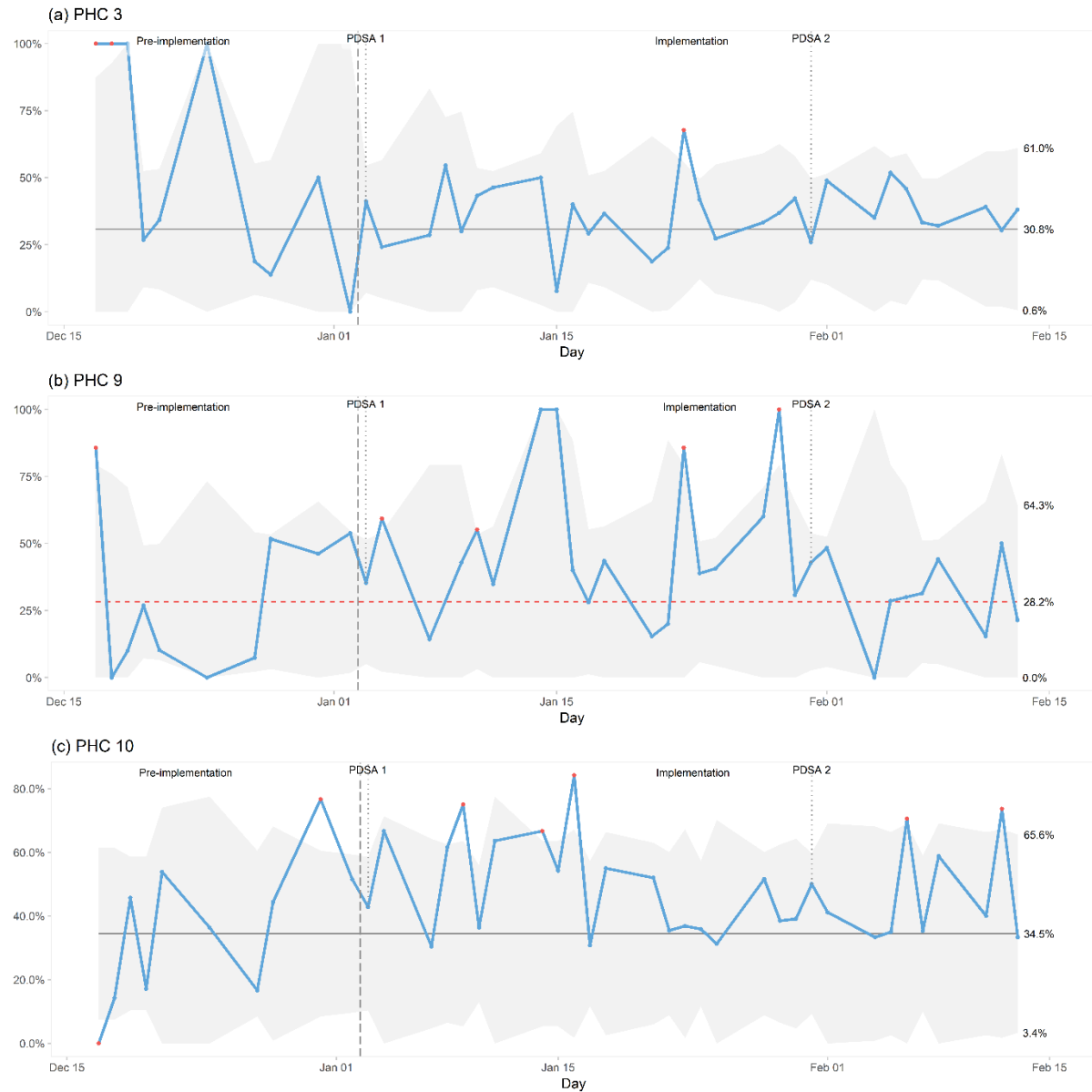


Figure 6.8: Missed opportunities for vaccination in primary health care (PHC) facility 3, 9 and 10.

Balancing measure

Supplementary material 6 shows the antenatal care attendance per day in the PHC facilities. In the facilities that implemented QI, two astronomical points were seen.

6.4.3 Interrupted time series analysis of the effect of QI programme in PHC 1 and 5

For PHC 1, The Durbin-Watson test yield a D-W statistic of 1.45 with p-value of 0.032 at lag of 1. In the autocorrelation function, exponential decay was seen as the lags got further apart. In the partial autocorrelation plot, a significant lag was seen at 1. Therefore we likely had an autoregressive process of order 1. The plot is attached as **Supplementary material 6.6**. For PHC 5, the D-W statistic farthest from 2 was 2.23 at lag of 3, however the p-value was 0.496. But the autocorrelation function indicated exponential decay and the partial autocorrelation function showed significant lag at 3 (as shown in **Supplementary material 6.7**). Therefore the correlation structure is likely an autoregressive process of order 3. The generalized least square regression model showed that in both PHC 1 and 5, the time coefficient (PHC1 (-0.07, 95%CI: -0.12 to -0.02) and PHC5 -0.06, 95%CI: -0.09 to -0.03) were negative thus indicating that following the commencement of quality improvement programme, there was some reduction in the proportion of MOV over time. Other coefficients are shown on **Table 6.3**. For PHC1, L-R ratio was 1.26 with p-value of 0.261. L-R ratio was 0.58 with p-value of 0.445 for PHC5.

Table 6.3: Coefficients of time series specifications for PHC1 and PHC5 in Nassarawa LGA, Kano

Facilities	Time series specifications		
	Time (95%CI)	Level(95%CI)	Trend(95%CI)
PHC 1	-0.07* (-0.12 to -0.02)	0.09 (-0.17 to 0.36)	0.07* (0.02 to 0.12)
PHC 5	-0.06* (-0.09 to -0.03)	0.001 (-0.15 to 0.15)	0.07* (0.04 to 0.10)

PHC = Primary health care; CI = Confidence interval; * indicates statistical significance

6.5 Discussion

6.5.1 Key findings

In this study, our objective was to implement a quality improvement programme for addressing MOV among children aged 0 – 23 months attending PHC facilities in Nassarawa LGA, Kano. Using divergent-convergent thinking, frontline health workers from PHC facilities selected change ideas that were tailored to their local contexts. These change ideas were multi-faceted, and they included: placing reminder tags on the patient cards, placing posters and charts with information about MOV prominently in the facilities and consulting room, conducting daily routine immunization, procuring additional cold boxes to facilitate immunization at other service delivery points and initiating phone conversation with fathers of children that refuse vaccines. They were also multimodal as they were tested through two PDSA cycles. The ISF was applied to guide their implementation using context-appropriate strategies. Evidence of improvement in process measures were observed in the facilities that implemented QI interventions. Improvement in the outcome measure was most apparent in PHC 1 and PHC 5.

6.5.2 Strengths and limitations

This study has limitations. Primary data collection was conducted by trained interviewers (that were external to the system) and this could have also influenced the behavior of health workers. However, MOV assessments are not conducted routinely as such there are no reliable program data on MOV that could have been used for this study. Data was analyzed per day, however, the volume of children that attend clinic for immunization services on Wednesdays, Thursdays and Fridays are more because of the scheduling that was initially in place. But this was an initial analysis to demonstrate proof of concept. There was a trade-off on internal validity because of the use of purposive sampling to select the facilities where QI was implemented. PHC facilities are inherently non-equivalent. There are varying exogenous factors, some of which are even unique to some facilities. However the immunization programme is implemented across PHCs regardless. There was also potential for design contamination as facility immunization focal persons meet regularly to review performance. Nevertheless, our main interest was to advance

existing knowledge on how QI can be implemented in a “real life” practice setting within a low income, low immunization coverage area. Moreover, the evidence that local policy makers need to support QI programmes in PHC facilities should place more emphasis on relevance and applicability of change ideas and implementation strategies, as well as external validity (46). Our study has some strengths. Stakeholders were systematically involved in the planning and execution of the QI programme. The change ideas were selected by frontline health workers and they tailored them to their local context. Also, change ideas are multi-faceted and multimodal and this are suitable for addressing complex problems in complex health systems. We evaluated the impact of the change ideas in a real-world context and this can ease scalability and transfer to other settings.

6.5.3 Implementation and evaluation of the QI programme in Nassarawa, Kano

In recent years, increasing access to childhood immunization has garnered considerable attention globally, and in Africa (47). In the 2016 Addis Ababa declaration on immunization, African ministers of health affirmed the role of vaccines in reducing child death and pledged to advance universal access to the lifesaving intervention for all children that needs it (48). The WHO has identified MOV as contributors to low immunization coverage and recommended the use of tailored strategies in addressing them (35). Tailoring strategies to local context can improve innovation fit and acceptability among local stakeholders. In this study, we developed multi-faceted and multi-modal change ideas that were tailored to the local context. The change ideas are multi-faceted as they targeted different stakeholders and multimodal because they involved multiple activities.

Frontline health workers were responsible for selecting the change ideas in this study. This can promote stronger commitment and ownership. Moreover, service providers are likely to know what a better fit for their setting would be. For example, reminder tags were used to prompt health workers about immunization history. But it was decided that this tag should be paper based rather than electronic as is obtainable in some settings (30). Taking the local context into consideration, it was judged that electricity is not constant and using mobile short messaging services would increase cost. Five data points (out of thirty) (for proportion of MOV per day)

went below the center line after the second PDSA cycle. This was a direct consequence of adding vaccine cold boxes to the change ideas to promote immunization service integration.

In this study, context-specific change ideas were combined with context-appropriate implementation strategies. In previous literature, factors such as buy-in from leadership, stakeholders' engagement, and innovation fit have been found to affect successful implementation of quality improvement programmes (13, 49). To mitigate this, multilevel collaboration was adopted, and stakeholders were empowered to monitor their performance using run charts. In Kano, there is strong political commitment to immunization, and this was leveraged to support the QI programme (50). Therefore, health policy gatekeepers and health systems managers at both state and LGA level as well as frontline health workers were involved in planning, need assessment, performance monitoring and capacity building. This promoted shared understanding and interest in quality improvement, and willingness to participate in the programme. Applying ISF enabled consideration for the specific needs of various stakeholders that are necessary for successful implementation of the QI programme (23).

So far, this QI programme has predominantly focused on screening of HBR which was identified as one of the leverage points for interventions in a causal loop diagram of factors associated with MOV (7). This loop hypothesized that health workers practices can influence routine screening of HBR which can in turn affect MOV (7). In fact, assessing and checking the immunization status of children when they come in contact with a health facility and ensuring that they receive recommended vaccines is considered a quality standard for paediatric care (51). Following the intervention, we found a substantial improvement in HBR screening per day among children attending the health facilities. The benefit of instituting routine screen of HBR at all service points is to enable health worker to identify those children who are not fully immunized for age during that visit and link them to immunization services. Thus, promoting HBR screening in this QI programme contributes to the overall quality of childcare in the PHC facilities.

However, we didn't observe a consistent improvement in the percentage of children who received immunization per day, although periodic spikes occurred. Also, a reduction in the proportion of MOV per day was evident in only two of the five facilities. This is not surprising as the programme was implemented under real-world circumstances. Possible reasons why improvement were not seen in other facilities could include factors related to the intervention

itself, the characteristics of individuals involved in its implementation, the inner setting of the PHCs, external context or implementation process (52). These can include shortage of antigens in facilities, knowledge and capacity gap among other health workers since only the facility QI teams were engaged in the main training. Also, the level of commitment from the QI teams might differ across facilities. In addition, no financial incentives were provided for health workers that participated in the QI programme and this might have affected their motivation. Furthermore, the PDSA cycles focused largely on one leverage point (7).

Evidence of improvement in the outcome measure was seen in facilities that did not implement the QI programme, although baseline performance was better in these facilities. Nevertheless, health workers in PHCs are highly interconnected and RI focal persons meet on monthly basis to review immunization data and share experiences. It is possible that these other facilities modified their system based on information from co-health workers, research activities being conducted, and monitoring activities by LGA officials.

Interestingly, the QI programme did not affect antenatal attendance in the facilities despite the engagement of the head of maternity in the QI teams. This is likely because the maternity sections had adequate manpower as such engaging the head didn't impact on service delivery.

6.5.4 Implications for policy

There is a need for state and LGA stakeholders to sustain this QI programme in PHC facilities as it has begun to yield improvement in some facilities. Additional data can inform policy decisions to scale up the programme to other facilities. There is also a need to institute routine assessment of MOV in PHC facilities. As a low immunization coverage area, it's important to keep track of MOV with routine facility data.

6.5.5 Implications for future research

Using the EPICOT+ framework, we suggested the follow research recommendations in **Box 6.1**.

Box 6.1: Use of EPICOT+ to highlight research recommendations	
Element	Recommendation(s)
	Core elements
Evidence (State of evidence)	Dearth of evidence on use of quality improvement to address MOV in Nigeria and other LMICs.
Population (Population of interest)	QI programmes to reduce MOV should target children aged 0 – 23 months in rural areas
Interventions	Multi-faceted, multi modal interventions that are context specific. Facility-specific change ideas should be incorporated.
Comparisons	Control (non-intervention) health facilities in other areas
Outcomes	Outcome, process and balancing measures
Time stamp	March 2019
	Optional element
Study type	<ol style="list-style-type: none"> Interrupted time series design with comparison group (weekly data points over one-year period). Pretest-posttest with comparison groups with substantial amount of time between pretest and posttest. Pragmatic trials Implementation-effectiveness hybrid trials

6.6 Conclusion

This study demonstrated that frontline health workers are capable of tailoring change ideas to their local context to generate context-specific change ideas. In addition, we also showed how the ISF can be used to guide the implementation of change ideas using context-appropriate implementation strategies in a QI programme in primary health care settings. A key insight from this study is that applying uniform change ideas and implementation strategies across facilities is

not likely to yield uniform rate of progress towards improvement. In subsequent PDSA cycles, it is important to incorporate more granular facility-specific change ideas in the PHC facilities that haven't begun to show evidence of improvement.

6.7 Competing interest

None declared

6.8 Author contribution

The study was conceptualized by AAA. He conducted the statistical analysis, interpreted findings, produced the first draft, and revised subsequent drafts. CSW, OAU, MAG reviewed and approved the study concept, supervised and contributed to analysis and interpretation, and manuscript development.

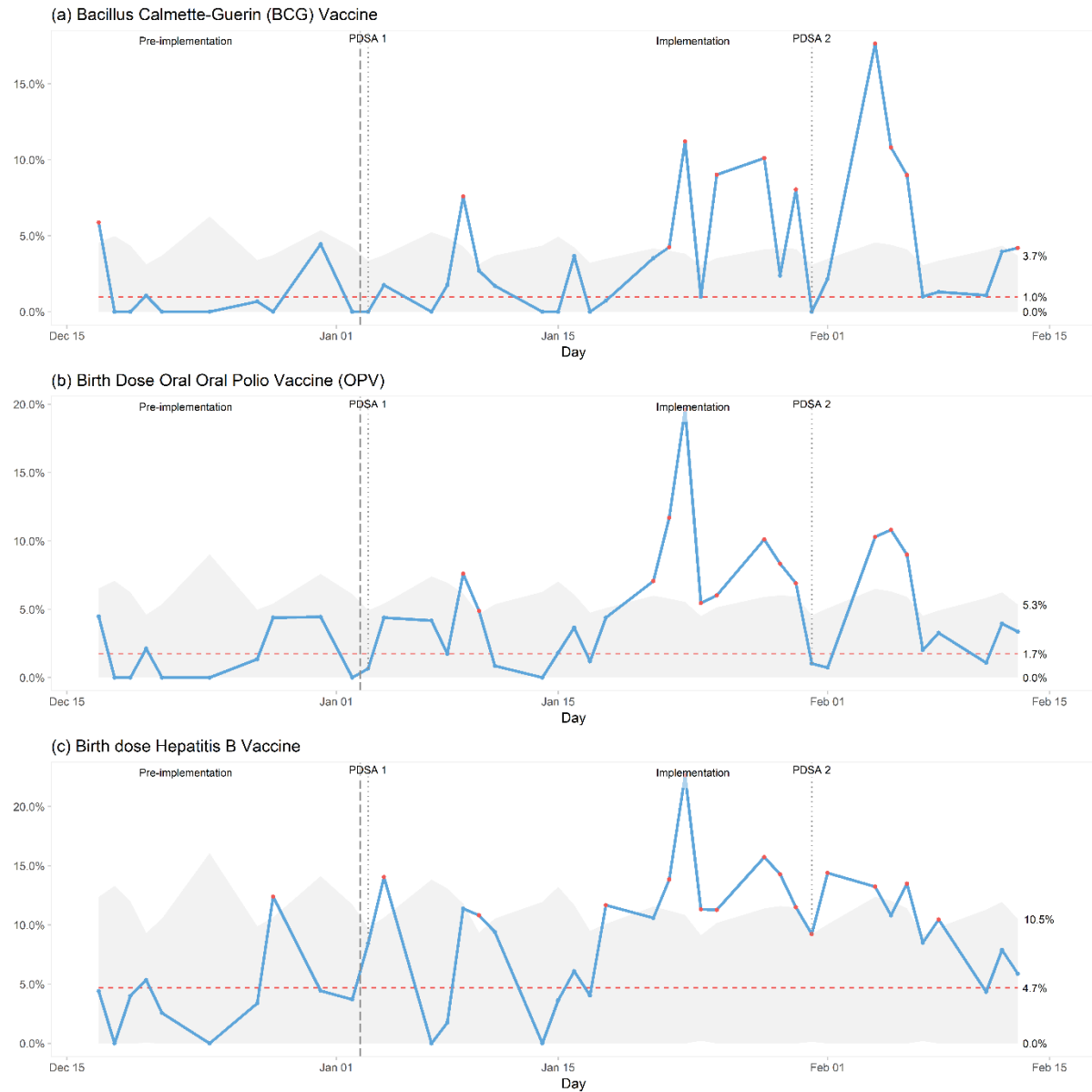
6.9 References

1. Adedokun ST, Uthman OA, Adekanmbi VT, Wiysonge CS. Incomplete childhood immunization in Nigeria: a multilevel analysis of individual and contextual factors. *BMC public health*. 2017;17(1):236.
2. Hutchins SS, Jansen HA, Robertson SE, Evans P, Kim-Farley RJ. Studies of missed opportunities for immunization in developing and industrialized countries. *Bull WHO*. 1993;71(5):549-60.
3. Onyiriuka A. Vaccination default rates among children attending a static immunization clinic in Benin City, Nigeria. 2005.
4. Tagbo B, Onwuasigwe C. Missed immunization opportunities among children in Enugu. *Nigerian Journal of Paediatrics*. 2005;32(4):73-6.
5. Ubajaka F, Ukegbu A, Okafor N, Ejiofor O. The prevalence of missed opportunities for immunization among children utilizing immunization services in NNAMDI AZIKIWE University Teaching Hospital, NNEWI. *J Biol Agric Healthc*. 2012;6(2).
6. Uthman OA, Sambala EZ, Adamu AA, Ndwandwe D, Wiyeh AB, Olukade T, et al. Does it really matter where you live? A multilevel analysis of factors associated with missed opportunities for vaccination in sub-Saharan Africa. *Human vaccines & immunotherapeutics*. 2018;14(10):2397-404.
7. Adamu AA, Sarki AM, Uthman OA, Wiyeh AB, Gadanya MA, Wiysonge CS. Prevalence and dynamics of missed opportunities for vaccination among children in Africa: applying systems thinking in a systematic review and meta-analysis of observational studies. *Expert Rev Vaccines*. 2019;18(5):547-58.
8. Committee on Quality of Health Care in America, Institute of Medicine. Crossing the quality chasm: A new health system for the 21st century. Washington DC, United States: National Academy Press; 2001.
9. Berwick DM, Nolan TW, Whittington J. The triple aim: care, health, and cost. *Health Aff (Millwood)*. 2008;27(3):759-69.
10. Shojania KG, Grimshaw JM. Evidence-based quality improvement: the state of the science. *Health Aff (Millwood)*. 2005;24(1):138-50.
11. Adamu AA, Uthman OA, Wambiya EO, Gadanya MA, Wiysonge CS. Application of quality improvement approaches in healthcare settings to reduce missed opportunities for childhood vaccination: a scoping review. *Human vaccines & immunotherapeutics*. 2019:null-null.
12. Taylor MJ, McNicholas C, Nicolay C, Darzi A, Bell D, Reed JE. Systematic review of the application of the plan-do-study-act method to improve quality in healthcare. *BMJ Qual Saf*. 2014;23(4):290-8.
13. Powell AE, Rushmer R, Davies H. A systematic narrative review of quality improvement models in health care: NHS Quality Improvement Scotland; 2009.
14. Courtlandt CD, Noonan L, Feld LG. Model for improvement-Part 1: A framework for health care quality. *Pediatric Clinics of North America*. 2009;56(4):757-78.
15. National Primary Healthcare Development Agency and National Bureau of Statistics. Nigeria National Immunization Coverage Survey 2016/17, Final Report. Abuja, Nigeria: National Primary Healthcare Development Agency and National Bureau of Statistics; 2017.

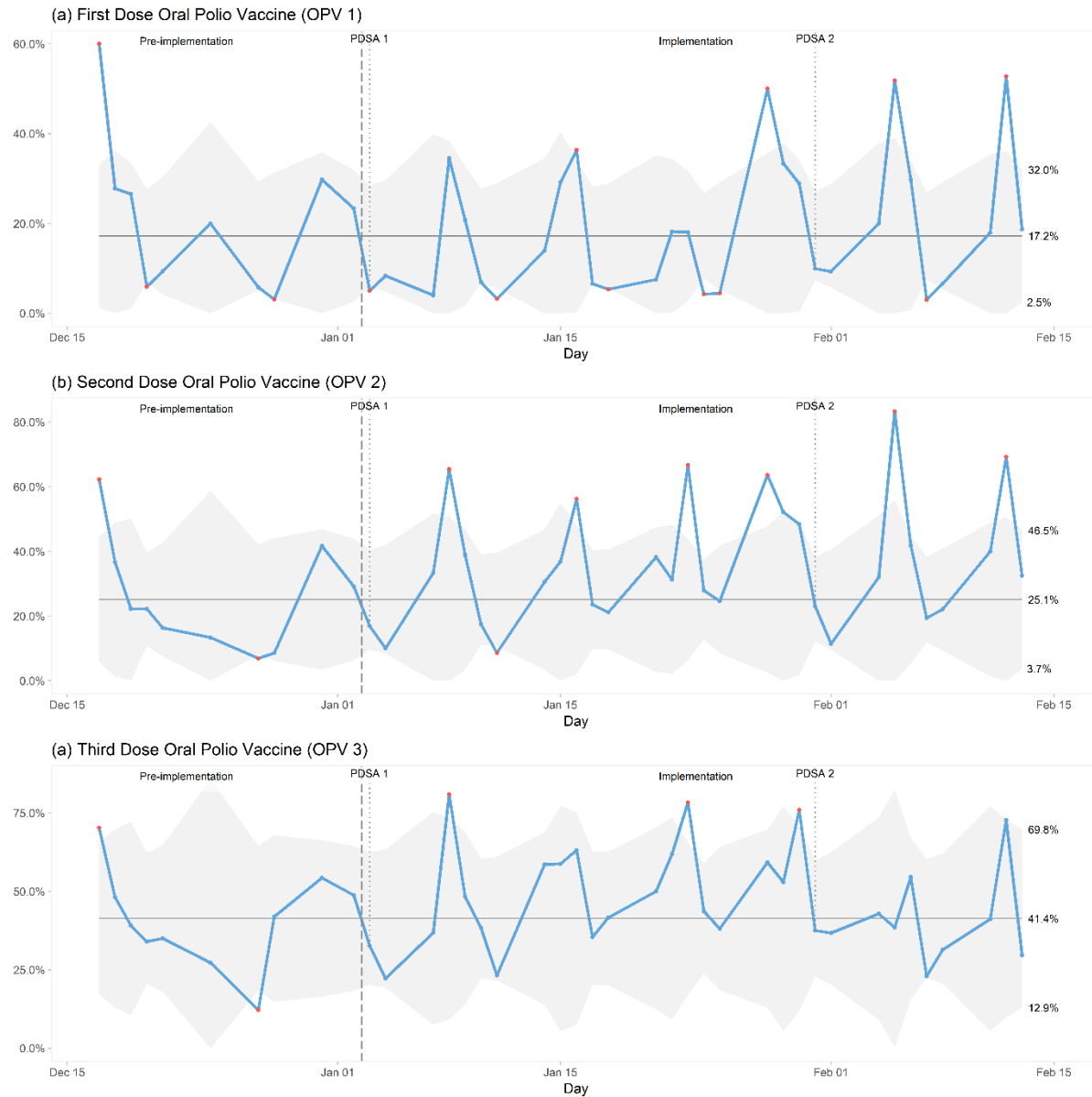
16. Adamu AA, Uthman OA, Wambiya EO, Gadanya MA, Wiysonge CS. Application of quality improvement approaches in health-care settings to reduce missed opportunities for childhood vaccination: a scoping review. *Human vaccines & immunotherapeutics*. 2019;1-10.
17. Daley MF, Steiner JF, Kempe A, Beaty BL, Pearson KA, Jones JS, et al. Quality improvement in immunization delivery following an unsuccessful immunization recall. *Ambulatory pediatrics : the official journal of the Ambulatory Pediatric Association*. 2004;4(3):217-23.
18. Daly KL, Halon PA, Aronowitz T, Ross G. A University Health Initiative to Increase Human Papillomavirus Vaccination Rates. *The Journal for Nurse Practitioners*. 2016;12(6):e281-e6.
19. World Health Organization. Practical guide for the design, use and promotion of home-based records in immunization programmes. Geneva, Switzerland: World Health Organization; 2015. Report No.: 9241508957.
20. Wandersman A, Alia KA, Cook B, Ramaswamy R. Integrating empowerment evaluation and quality improvement to achieve healthcare improvement outcomes. *BMJ Qual Saf*. 2015;24(10):645-52.
21. Jacobs SR, Weiner BJ, Reeve BB, Hofmann DA, Christian M, Weinberger M. Determining the predictors of innovation implementation in healthcare: a quantitative analysis of implementation effectiveness. *BMC health services research*. 2015;15(1):6.
22. Meyers DC, Durlak JA, Wandersman A. The quality implementation framework: a synthesis of critical steps in the implementation process. *Am J Community Psychol*. 2012;50(3-4):462-80.
23. Wandersman A, Duffy J, Flaspohler P, Noonan R, Lubell K, Stillman L, et al. Bridging the gap between prevention research and practice: The interactive systems framework for dissemination and implementation. *American journal of community psychology*. 2008;41(3-4):171-81.
24. Fetterman DM, Kaftarian SJ, Wandersman A. Empowerment evaluation: Knowledge and tools for self-assessment and accountability: Sage; 1996.
25. Cheung YY, Jung B, Sohn JH, Ogrinc G. Quality initiatives: statistical control charts: simplifying the analysis of data for quality improvement. *Radiographics*. 2012;32(7):2113-26.
26. Benneyan J, Lloyd R, Plsek P. Statistical process control as a tool for research and healthcare improvement. *BMJ Quality & Safety*. 2003;12(6):458-64.
27. Goodman D, Ogrinc G, Davies L, Baker GR, Barnsteiner J, Foster TC, et al. Explanation and elaboration of the SQUIRE (Standards for Quality Improvement Reporting Excellence) Guidelines, V.2.0: examples of SQUIRE elements in the healthcare improvement literature. *BMJ Qual Saf*. 2016;25(12):e7.
28. Scott-Emuakpor A. The evolution of health care systems in Nigeria: Which way forward in the twenty-first century. *Nigerian Medical Journal*. 2010;51(2):53-.
29. National Primary Health Care Development Agency. The National Immunization Schedule in Nigeria Abuja, Nigeria [cited 2019 5th February 2019]. Available from: <http://nphcda.gov.ng/?ddownload=673>.
30. Jaca A, Mathebula L, Iweze A, Pienaar E, Wiysonge CS. A systematic review of strategies for reducing missed opportunities for vaccination. *Vaccine*. 2018;36(21):2921-7.
31. Moen RD, Nolan TW, Provost LP. Quality improvement through planned experimentation: McGraw-Hill New York; 1999.

32. Lewis CC, Klasnja P, Powell BJ, Lyon AR, Tuzzio L, Jones S, et al. From Classification to Causality: Advancing Understanding of Mechanisms of Change in Implementation Science. *Front Public Health*. 2018;6(136):136.
33. Series B, Kilo CM. A framework for collaborative improvement: lessons from the Institute for Healthcare Improvement's Breakthrough Series. *Quality management in health care*. 1998;6(4):1-13.
34. World Health Organization. Methodology for the Assessment of Missed Opportunities for Vaccination. Geneva, Switzerland 2017.
35. World Health Organization. Planning guide to reduce missed opportunities for vaccination. Geneva, Switzerland: World Health Organization; 2017.
36. Habicht JP, Victora CG, Vaughan JP. Evaluation designs for adequacy, plausibility and probability of public health programme performance and impact. *International journal of epidemiology*. 1999;28(1):10-8.
37. Makama SD. 2006 National Population and Housing Census. Abuja: National Population Commission, Commission NP; 2010.
38. National Population Commission. Population and housing census of the Federal Republic of Nigeria. Priority tables. 2006;1.
39. Wright A. REDCap: a tool for the electronic capture of research data. *Journal of Electronic Resources in Medical Libraries*. 2016;13(4):197-201.
40. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of biomedical informatics*. 2009;42(2):377-81.
41. Duclos A, Voirin N. The p-control chart: a tool for care improvement. *International Journal for Quality in Health Care*. 2010;22(5):402-7.
42. Kontopantelis E, Doran T, Springate DA, Buchan I, Reeves D. Regression based quasi-experimental approach when randomisation is not an option: interrupted time series analysis. *BMJ*. 2015;350:h2750.
43. Anhøj J. qicharts: Quality Improvement Charts. R package version 01. 2014;2.
44. Bates D. Fitting linear mixed models in R. *R news*. 2005;5(1):27-30.
45. Fox J, Weisberg S, Adler D, Bates D, Baud-Bovy G, Ellison S, et al. Package 'car'. Vienna: R Foundation for Statistical Computing. 2012.
46. Green LW, Glasgow RE. Evaluating the relevance, generalization, and applicability of research: issues in external validation and translation methodology. *Eval Health Prof*. 2006;29(1):126-53.
47. World Health Organization. Global vaccine action plan 2011-2020. Geneva, Switzerland: World Health Organization; 2013.
48. African Union Commission and World Health Organization Regional Office for Africa. Roadmap for Implementing the Addis Declaration on Immunization: Advocacy, Action, and Accountability. Addis Ababa, Ethiopia: African Union Commission and World Health Organization, ; 2017.
49. Dixon-Woods M, McNicol S, Martin G. Ten challenges in improving quality in healthcare: lessons from the Health Foundation's programme evaluations and relevant literature. *BMJ Qual Saf*. 2012;21(10):876-84.

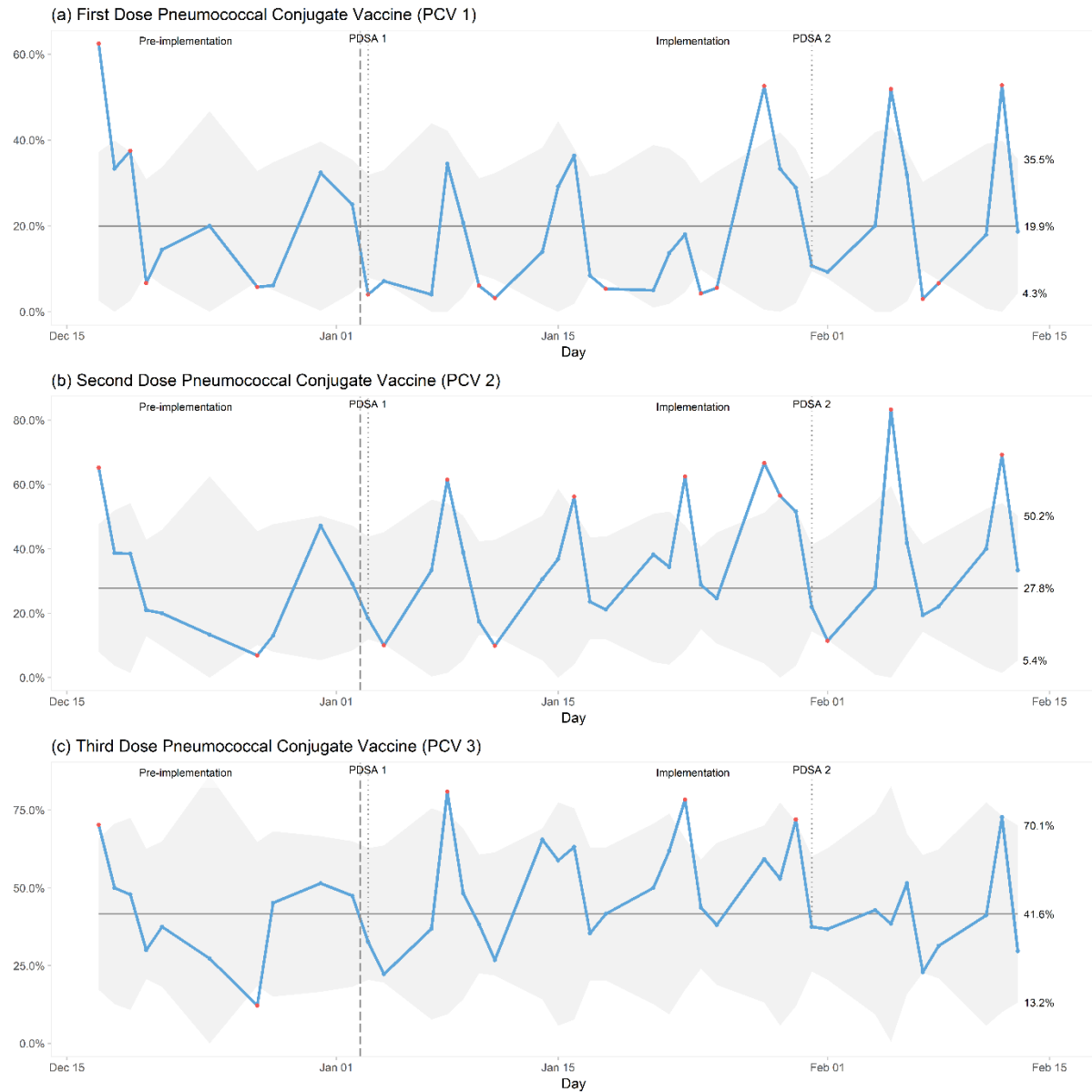
50. Abba B, Abdullahi S, Bawa S, Getso KI, Bello IW, Korir C, et al. Mobilizing political support proved critical to a successful switch from tOPV to bOPV in Kano, Nigeria 2016. *BMC public health*. 2018;18(Suppl 4):1302.
51. World Health Organization. Standards for improving the quality of care for children and young adolescents in health facilities. Geneva, Switzerland.2018.
52. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. *Implementation science*. 2009;4(1):50.



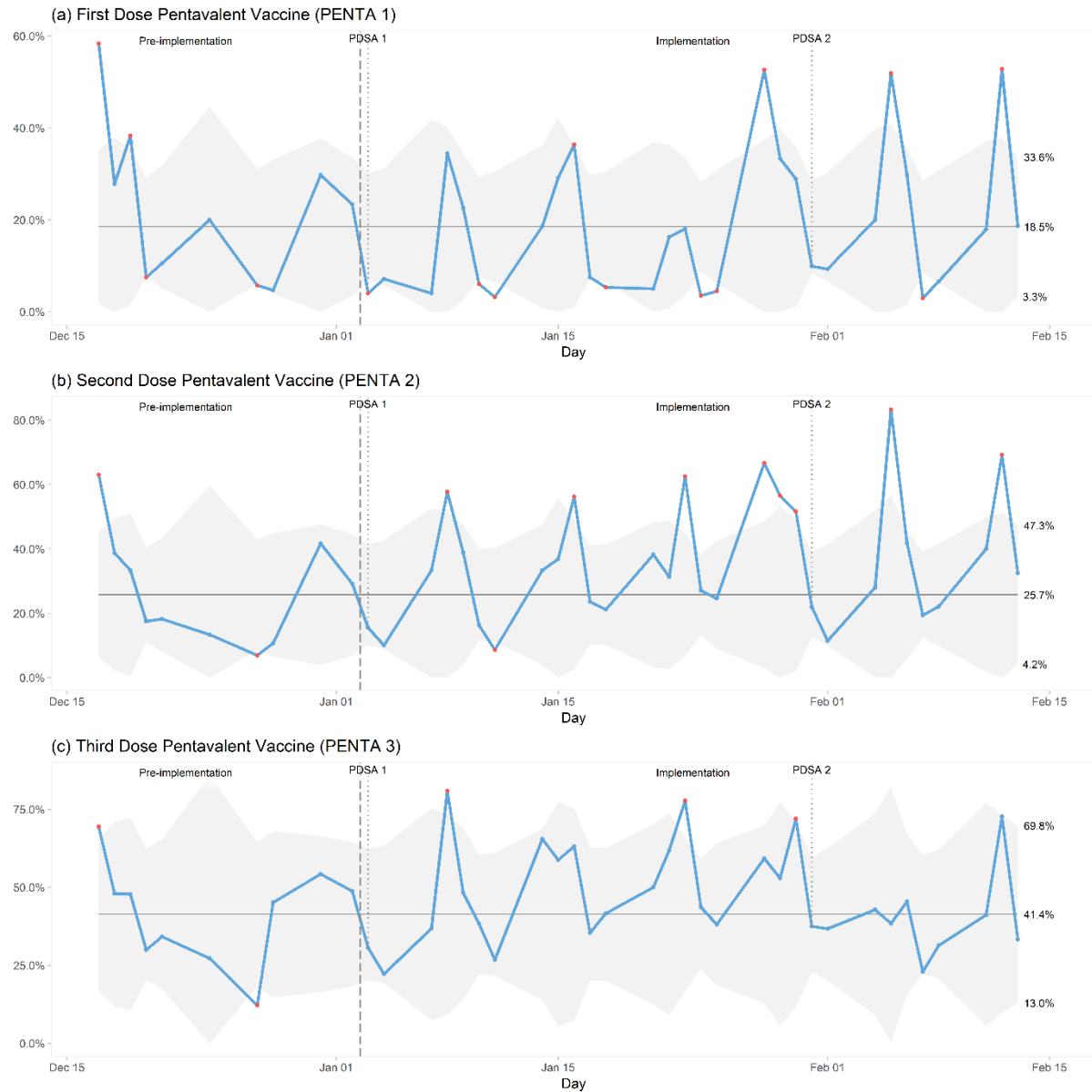
Supplementary material 6.1: Missed opportunities for vaccination for birth dose oral polio vaccine, bacillus Calmette-Guerin vaccine and birth dose hepatitis B vaccine in PHC facilities in Nassarawa, Kano



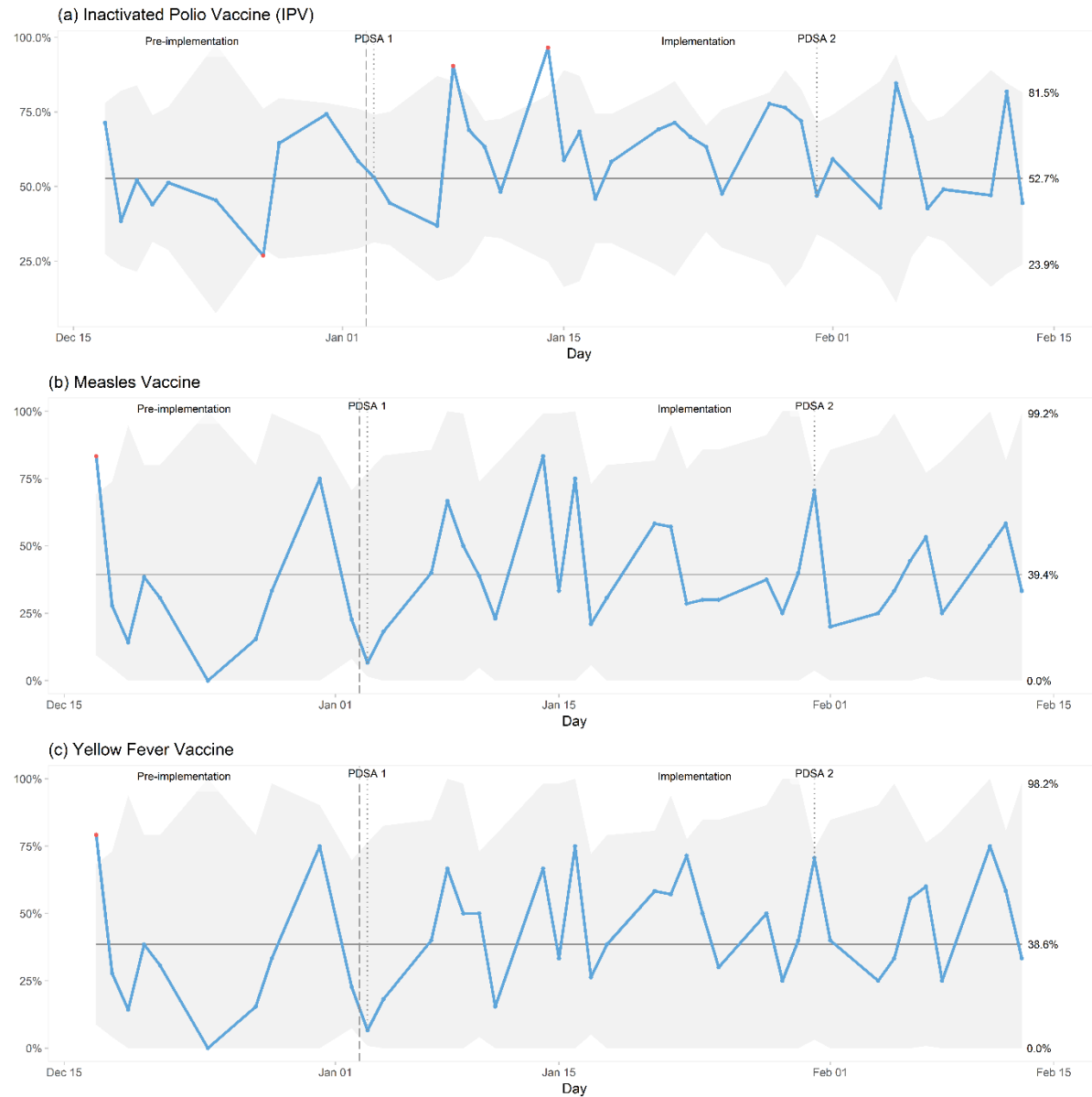
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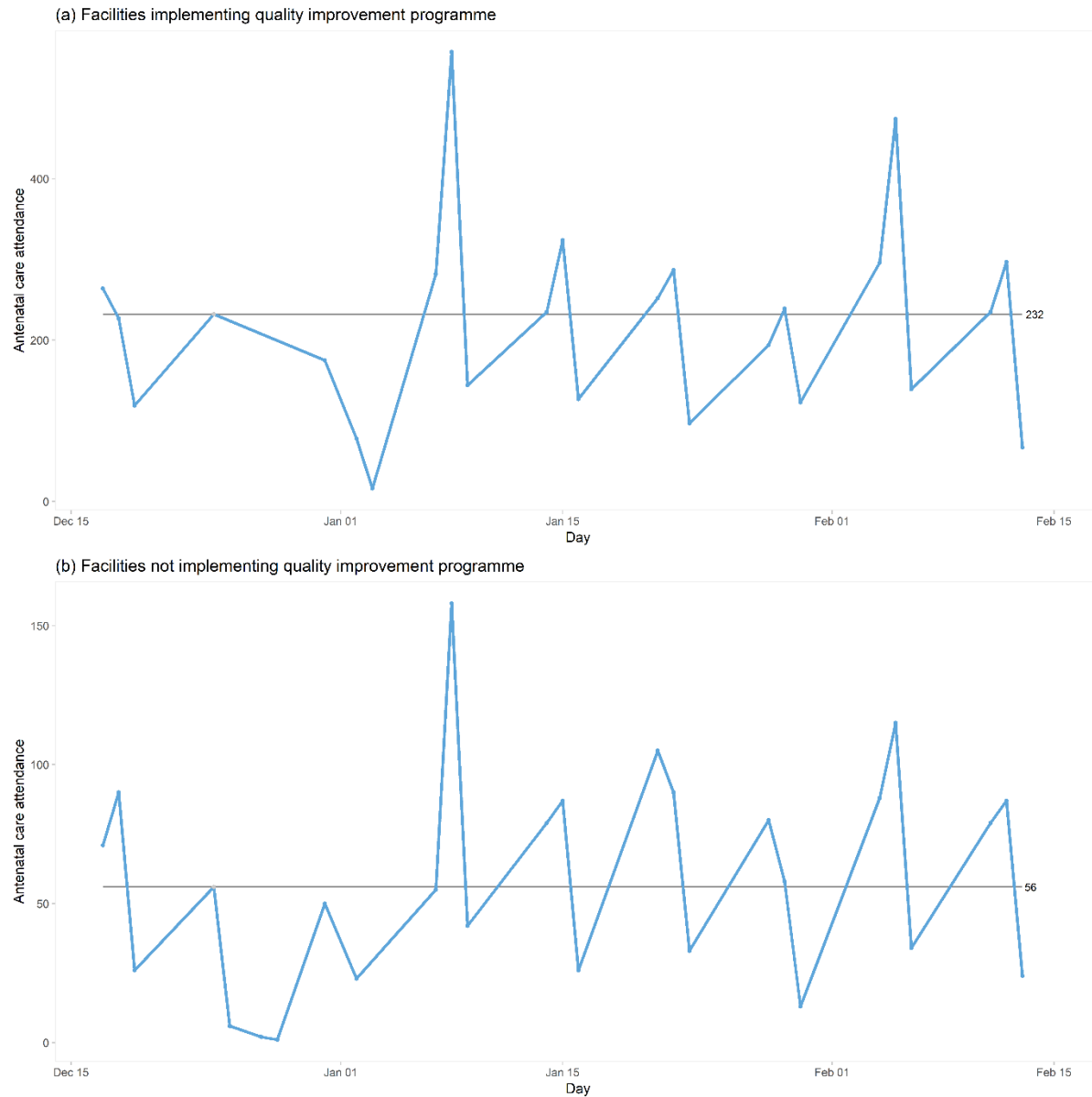
Supplementary material 6.3: Missed opportunities for vaccination for first, second and third dose of pneumococcal conjugate vaccine in PHC facilities in Nassarawa, Kano



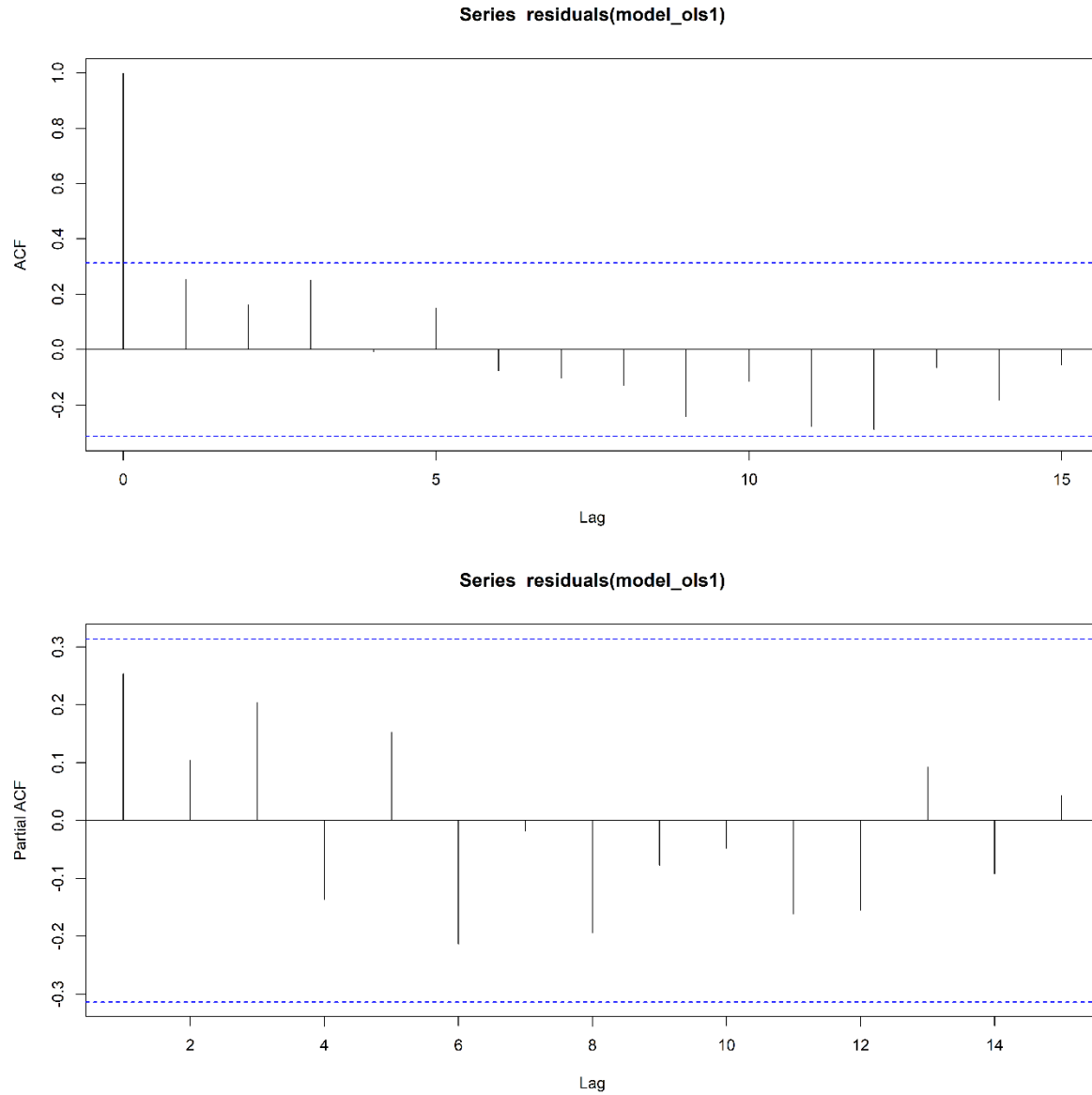
Supplementary material 6.4: Missed opportunities for vaccination for first, second and third dose of pentavalent vaccine in PHC facilities in Nassarawa, Kano



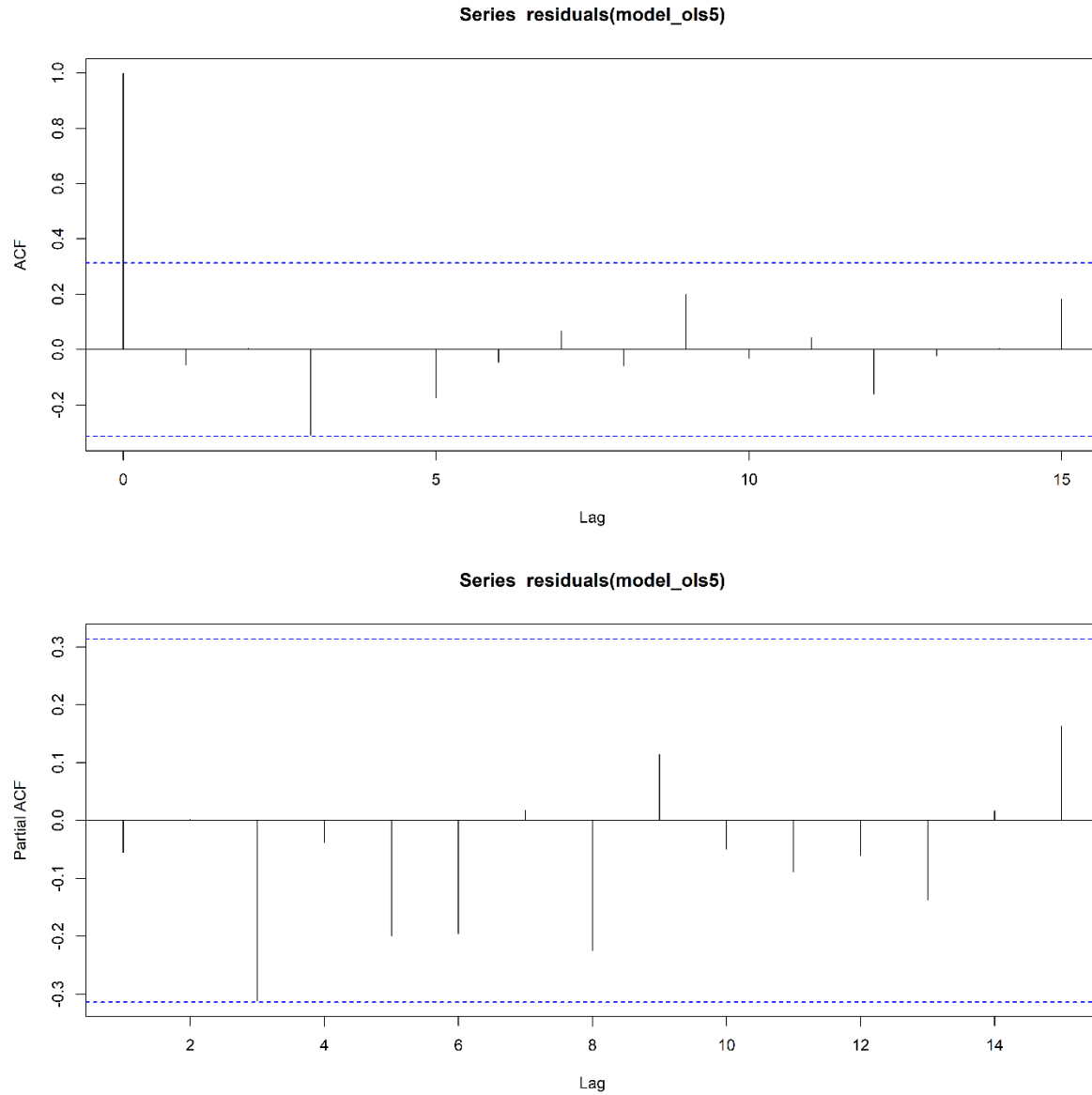
Supplementary material 6.5: Missed opportunities for vaccination for inactivated polio vaccine (IPV), measles vaccine and yellow fever vaccine in PHC facilities in Nassarawa, Kano



Supplementary material 6.6: Antenatal care attendance in PHC facilities in Nassarawa, Kano



Supplementary material 6.7: Autocorrelation function and partial autocorrelation function for PHC1 in Nassarawa, Kano



Supplementary material 6.7: Autocorrelation function and partial autocorrelation function for PHC5 in Nassarawa, Kano

Chapter 7: Using the consolidated framework for implementation research (CFIR) to assess the implementation context of a quality improvement programme to reduce missed opportunities for vaccination in Kano, Nigeria: a mixed methods study

7.0 About this chapter

In this chapter, we report a mixed methods study of the implementation context of the quality improvement programme implemented in Nassarawa, Kano, to reduce missed opportunities for vaccination among children. This chapter has been published by Taylor and Francis Group in *Human Vaccines and Immunotherapeutics* on 23rd September 2019, and can be accessed through the following link: <https://doi.org/10.1080/21645515.2019.1654798>. The full citation is as follows: Abdu A. Adamu, Olalekan A. Uthman, Muktar A. Gadanya & Charles S. Wiysonge. Using the consolidated framework for implementation research (CFIR) to assess the implementation context of a quality improvement programme to reduce missed opportunities for vaccination in Kano, Nigeria: a mixed methods study. *Human Vaccines & Immunotherapeutics* 2019; 15(10):1-10. DOI: 10.1080/21645515.2019.1654798. Epub 2019 Aug 19.

7.1 Abstract

Background: Although understanding the implementation context is essential, there is a dearth of research on how to systematically explore it in quality improvement (QI) programmes. Therefore, in this study, we used the consolidated framework for implementation research (CFIR) to guide a systematic evaluation of the implementation context of an ongoing QI programme in order to generate rapid site-specific feedback that can be used to improve subsequent plan-do-study-act (PDSA) cycles.

Method: Formative cross-case evaluation was conducted using convergent mixed methods design. The study was conducted in five primary health care (PHC) facilities (PHC 1, PHC 3, PHC 5, PHC 9 and PHC 10) implementing the QI programme. Health workers in those facilities formed the study population. Quantitative data was collected using a self-administered, Likert-based rating tool, while qualitative data collection was guided by an interview guide. The interviews were transcribed verbatim, and thematic analysis was performed. Raw median score and factor scores were computed. Methodological integration occurred at the design, analysis and reporting stage.

Result: A total of 165 health workers were included in this study with a mean age of 33.43 years (standard deviation of 7.15). Majority were females and they all had post-secondary education. Health workers in two facilities; PHC 1 and PHC 5, reported higher scores for the QI programme across all five domains of CFIR. Implementation facilitators included intervention flexibility, relative advantage, self-efficacy among health workers, health workers confidence in the intervention, services integration. While implementation barriers included vaccine stock outs, faulty cold chain infrastructure, lack of incentives, and socio-cultural beliefs.

Conclusion: This study demonstrated that theory-driven formative evaluation can be integrated in QI programmes in a low resource setting. It buttressed the value in conducting such assessment as they can be used to generate rapid feedback on factors that influence implementation success which can then be addressed in subsequent cycles.

7.2 Introduction

Missed opportunities for vaccination (MOV), which refers to any contact with a health facility by an unvaccinated or partially vaccinated child which does not result in the child receiving their recommended vaccines, is an indicator of poor quality of care for children in healthcare services (1, 2). This is because routine screening of immunization history followed by prompt provision of required vaccines are part of the quality of care standards for pediatric services (2). In an effort to reduce MOV in primary health care (PHC) facilities in Nassarawa Local Government Area (LGA) of Kano State, Nigeria, health workers co-designed and implemented a collaborative facility-based quality improvement (QI) programme. MOV was said to have occurred if a child aged 0 – 23 months who is eligible for immunization, makes contact with any of the PHC facilities and fails to receive all their recommended antigens. Kano, like many states in the geopolitical zone has low immunization coverage level that is significantly below the Global Vaccine Action Plan (GVAP) target (3). As such, a QI programme that seeks to improve immunization coverage by strengthening facility “in-reach” effort is an imperative (1, 4).

After two plan-do-study-act (PDSA) cycles spanning a six weeks period, a decline in the proportion of MOV became apparent in two out of the five PHC facilities that were implementing the QI programme in Kano, Nigeria. However, this is not surprising as several studies have reported that in QI interventions, progress towards attainment of the desired health outcome can be inconsistent across settings (5, 6). It has been suggested that such variations may be due in part to the implementation context as local contextual factors can affect implementation process (7, 8). These factors may be related to stakeholders such as health care providers, users of health services, and health service managers among others (7). They can also be organizational, or policy related (7). Thus, investigating them while implementing a QI programme can provide additional information that can be used to modify subsequent rapid cycles to improve progress towards the desired outcomes across settings.

Recent advancements in implementation science have led to the proliferation of several frameworks and theories for studying implementation contexts (9-11). But most of these theories are often missing one or more domains that are necessary for explaining the complex attributes of contexts (12). Therefore, a meta-framework known as the Consolidated Framework for Implementation Research (CFIR) was developed by fusing domains from these

existing theories (12). This framework is comprehensive as it encompasses a wide array of domains that can affect implementation (12).

In this study, we explored the implementation context of five PHC facilities that are implementing a QI programme to reduce MOV through the lens of the CFIR framework. This was to understand the facilitators of, and barriers to implementation success. CFIR has five main domains namely; intervention characteristics, outer setting, inner setting, individual characteristics and implementation process (12). There are 39 constructs distributed across these domains (12). The CFIR's overarching domains makes it suitable for assessing implementation context from a multi-level perspective (12). We defined each domain broadly. Intervention characteristics represented the features of the quality improvement intervention. Outer setting reflected the features of the external environment. Inner setting represented the features of the primary health care system where the programme is being conducted. Individual characteristics encompassed the features of the health worker, and implementation process referred to the strategies that were employed during the plan-do-study-act cycles.

There is a dearth of research on how to systematically explore the implementation context of an ongoing quality improvement programme. This study examined implementation context through a theory-driven formative assessment that was embedded within the QI programme (8). This enabled quick identification of site-specific barriers that needs to be addressed and facilitators that should be sustained or promoted in subsequent cycles. The added advantage of conducting theory-driven assessments is that they can yield more holistic information for programme improvement (13). The objective of this study was to examine the contextual factors that affect the implementation of a quality improvement programme to reduce missed opportunities for vaccination among children aged 0 – 23 months attending primary health care facilities in Nassarawa Local Government Area of Kano State, Nigeria.

7.3 Methods

7.3.1 Brief description of the QI Programme

Frontline health workers from five PHC facilities (coded as PHC 1, PHC 3, PHC 5, PHC 9 and PHC 10) co-designed a multifaceted and multimodal change package that was? being implemented in a QI programme. So far, two plan-do-study-act (PDSA) cycles had been implemented. The first PDSA cycles started on 3rd January 2019 with the following change ideas: placing of immunization reminder cards on the patient card of all persons attending the PHC with a child (or children) to prompt health workers to screen the child's (or children's) immunization history, distribution of MOV job aids in the facilities, modification of clinic schedule to enable daily immunization, and over-the-phone persuasion of husbands that refuse vaccination. This cycle lasted for four weeks. Then another cycle commenced on 31st January 2019 which retained all the change ideas from the first PDSA but added the distribution of additional vaccine cold boxes to service delivery points to promote integration of immunization services. Initial analysis at two weeks after commencement of the second PDSA cycle indicated that progress towards reduction in the proportion of MOV among children aged 0 – 23 months was apparent in PHC 1 and PHC 5.

7.3.2 Study design and research paradigm

A formative cross-case evaluation was conducted after commencement of the second PDSA cycle using a convergent mixed methods design (14). Mixed methods design, as opposed to single designs (qualitative or quantitative) can aid better understanding of complex implementation contexts within the PHC facilities (14). Leveraging on the advantage of this design, phenomena that would otherwise not have been identified using a single means were explored and identified (15). This design allowed for the collection of different but complementary data on factors that influenced the implementation of the QI programme. By combining the two data types, we gained complementarity of perspectives and used this to reconstruct the meaning of each CFIR domain for the study. Since CFIR, which is a pre-existing theoretical framework was used, a subtle realism paradigm was adopted from an epistemological perspective (12, 16).

7.3.3 Study setting

The study was conducted in five PHC facilities coded as PHC 1, PHC 3, PHC 5, PHC 9 and PHC 10 that were implementing a collaborative QI programme to reduce MOV. These facilities are located in Nassarawa Local Government Area (LGA). This LGA is one of the metropolitan LGAs in Kano State (18). It is located in Kano Central senatorial district. It has an area of about 35km² with a population of 596,669 according to the 2006 National Population and Housing Census (19, 20). The current projected population of the local government based on an annual growth rate of 3.3% is 880, 922.

7.3.4 Study population

Health workers (regardless of their cadre) that work in the five PHC facilities were included. To be eligible, the health worker had to be aged 18 years and above and have been working in the facility for at least 4 weeks. This was to ensure that they had participated in at least one full PDSA cycle.

7.3.5 Sampling and sample size

For the quantitative procedure, the entire population of eligible health workers in the PHC facilities were enrolled in the study. These included staff of all service delivery points including outpatient department, maternity, immunization among others. For the qualitative procedure, heads of units were purposively selected as key informants.

7.3.6 Data collection tool

Qualitative data collection tool: A semi-structured interview guide (attached as **Appendix 3**) was developed to elicit response from key informants. This interview guide explored the perspectives of health workers that led the QI programme in their facilities. The interview was flexible and allowed probing questions. The guide was pre-tested with health workers in Kano Municipality for clarity and appropriateness of questions.

Quantitative data collection tool: The CFIR was used to guide the *de novo* development of a semi-structured Likert-based QI implementation rating tool (attached as **Appendix 4**) that was used in this study (12). It was a 5-point Likert scale with responses ranging from strongly disagree to strongly agree. The tool had two sections; section 1 collected background

information while section 2 collected health workers' rating of the QI programme. The second section was structured based on the five domains of CFIR namely; intervention characteristics, inner setting, outer setting, characteristics of individuals, and implementation process (12). For each of the domains, items were developed. Intervention characteristics had eight items. Outer setting had four items. Inner setting had 12 items. Characteristics of individuals had four items. And implementation process had six items. The tool was iteratively revised for fluency, clarity and adequacy by the researchers. It was then tested with health workers in PHC facilities in Kano Municipal for the appropriateness of sentences, structure and order of questions. The health workers' feedback was that the tool was clear and simple to use.

7.3.7 Data collection

Qualitative data collection: Interviews were used to obtain data from key informants. These key informants were heads of units and they served in the facility QI teams. The interviews were conducted face-to-face in a private and quiet room within the facility. The interviewer and respondent sat opposite each other. Each interview session lasted about 45 minutes to one hour. Interviews were conducted in the afternoon to avoid interrupting service delivery. All interviews were recorded using a portable digital audio recorder. In each of the facilities, saturation was attained early, usually after the third interview, and an additional one or two interviews were conducted to confirm it. Reflection notes were kept and updated after each interview. An initial thematic analysis and coding was performed using summaries to note emerging themes. A total of 24 interviews were conducted across all five PHC facilities. Each of the 24 interviews was transcribed verbatim. All transcripts were reviewed for accuracy. In cases where a respondent made a sentence in Hausa language, this sentence was translated to English and back translated to the original language to ensure that its meaning was not lost in translation. All transcripts were reread multiple times.

Quantitative data collection: Data was collected using semi-structured self-administered QI implementation rating tool on mobile tablets. This was guided by an assistant. Data was collected in the afternoon after most patients had left to ensure minimal distraction and avoid any significant disruption of health service provision. To ensure that every health worker was included, the assistant returned to each facility the following day. Research Electronic Data Capture (REDCap) was used for data collection and management (20).

Both qualitative and quantitative data were collected between 6th – 15th February 2019.

7.3.8 Data analysis

Qualitative data analysis: Template analysis approach was used (21). After reading each transcript thoroughly, thematic content analysis was used to identify all factors that affected the implementation of the QI programme inductively. The codes that were generated from the transcripts were compared with the initial codes that were generated during data collection, and this informed some slight refinement of the themes. All the themes identified were placed in a codebook. In another codebook, the CFIR domains were specified. Then, the codes that were inductively developed from the transcripts were deductively mapped to the CFIR domains. These CFIR codes were analytical as they required the researcher to interpret data from interviews and apply them accordingly. Overlapping was avoided by re-reading. Quotes were used to support each theme. Also, illustrative quotes that reflected the experiences of health workers for each domain per facility were presented using a joint display table.

Quantitative data analysis: Firstly, the reliability coefficient of the items in each domain was calculated. Since the items are Likert scales, ordinal alpha was used (22). A polychoric correlation matrix was fitted and then used to compute the ordinal alpha (22). Ordinal alpha was used because it estimates reliability coefficients more precisely than Cronbach's alpha for ordinal variables (23). Raw median scores with their corresponding interquartile range (1st quartile – 3rd quartile) for each item within the domains was calculated per facility. Similarly, the median scores with their corresponding interquartile range (1st quartile – 3rd quartile) for each domain was also calculated per facility. Additionally, factor scores based on regression coefficients for each CFIR domain were computed in exploratory factor analysis. Bartlett test of sphericity and Kaiser-Meyer-Olkin measure of sampling adequacy were calculated for all items in each domain. Then, using the polychoric correlation matrix, factor analysis was performed. To decide on which factors to retain, we used factors with eigen values greater than 1 or point of inflection on scree plot or number of items loading on a particular factor. To ensure that the items are consistent with each other and factors are uncorrelated, orthogonal varimax rotation was used. The factors scores for each domain per facility were presented using a joint display table. Analysis was performed in R-Studio which is an integrated development environment for R using the package *psych* and STATA 14.2 College Station, Texas.

7.3.9 Integration of mixed methods

In this study, methodological integration occurred at three stages; design, analysis, and reporting. In the design stage, both qualitative and quantitative data were collected within the same time frame in February 2019. Although in parallel, both types of data were collected from same group of health workers. In the analysis stage, integration occurred through connecting. This is because the interview respondents were a subpopulation of the participants that participated in the survey. In the reporting stage, integration occurred through the use of joint display. This involved using a table to organize both quantitative and qualitative data.

7.3.10 Ethical approval

Ethical clearance for this study was obtained from Stellenbosch University Health Research Ethics Committee (with reference number: S18/02/044) (attached as **Appendix 5**), Kano State Ministry of Health (with reference number: MOH/Off/797/T.I/374) (attached as **Appendix 6**) and Aminu Kano Teaching Hospital (with reference number: NHREC/21/08/2008/AKTH/EC/2296) (attached as **Appendix 7**). An information sheet was read to respondents and written informed consent was obtained. It was clearly explained to the study participants that they could decline to respond to any of the questions or exit the study at any time. To ensure anonymity, identifiers were not collected.

7.4 Results

7.4.1 Characteristics of health workers

A total of 165 health workers were included in the study. As shown on **Table 7.1**, the mean age of the health workers was 33.43 with standard deviation of 7.15. Over half were aged 20 – 34 years. Majority of health worker were females, and all had a post-secondary qualification. 23% were community health workers.

Table 7.1: Background characteristics of health workers in primary health care facilities that implemented quality improvement programme in Nassarawa local government area of Kano State

Variable	Mean (SD)	Min; Max
Age	33.43 (7.15)	20; 52
Variables	Frequency	Percentage
Age group (in years)		
20 - 34	92.00	55.76
35 - 52	73.00	44.24
Sex		
Male	41.00	25.00
Female	124.00	75.00
Level of education		
No formal education	0.00	0.00
Primary education only	0.00	0.00
Secondary education	0.00	0.00
Post-secondary education	165.00	100.00
Cadre of health worker		
Community health worker	39.00	23.64
Environmental health assistant	32.00	19.39
Auxillary nurse	1.00	0.61
Registered nurse	0.00	0.00
Pharmacy technician	10.00	6.06
Pharmacist	2.00	1.21
Medical Doctor	0.00	0.00
Others	81.00	49.09

7.4.2 Qualitative findings

INTERVENTION CHARACTERISTICS

Flexibility and ease of implementation

Across the facilities, most of the health workers expressed that the quality improvement programme was easy to implement and flexible. We found that this evoked a desire for broader participation and several participants recommended that the programme be scaled up to other health facilities within the local government. One of the reasons why they considered it easy to implement was because of the teamwork that was involved:

“It is very easy. It is not only one person that conduct the activity. We joined our hands together, all the unit heads in the clinic.” – PCH 3

“To be specific the activities is very flexible because we met and deliberated on methods or initiatives that we will apply” – PHC 3

Others even felt that what is required is persuasion and expressed that it was not difficult:

“There is nothing difficult it is just to talk and convince the clients about the importance of this initiative.” – PHC 5

Relative advantage of QI

In most of the facilities, health workers expressed strong positive perception about the advantage of the quality improvement programme. They felt that it was a less time-consuming intervention since unimmunized children are detected in the health facility.

“I am sure this initiative is going to work.” – PHC 5

“We used to go out and look for unimmunized and defaulters, but this QI Initiative bring out the best ways to detect them at your own doorstep without wasting time.” – PHC 5

Some of the participants felt that the QI intervention is better than other interventions because it focuses on all the children that are visiting the health facility.

“It is better because now it involves everybody whether that person has come for immunization or not.” – PHC 10

INNER SETTING

Supportive supervision

The participants across facilities did not only acknowledge the importance of supervisory visits but affirmed that they received such visits while implementing the quality improvement programme. Participants expressed satisfaction with the supervisory plan that was put in place for the quality improvement programme as it enabled quick feedback. Supervisory visits were conducted by different stakeholders that are higher ranking officials within the health systems. These include local government and zonal primary health care management board officials.

“We receive supervision from local government, they use to come and supervised us to check how we conduct our duties.” – PHC 3

“the HOD had to come here for supervision to see how effective the intervention is.” – PHC

Vaccine cold chain

A participant in one of the facilities expressed an important gap in their inability to maintain vaccine cold chain which can affect the availability of antigens.

“We have solar refrigerator, but it is now faulty.” – PHC 5

However, as an adhoc measure to sustain availability of vaccines was put in place. This was informed by a shared perception of the importance of the quality improvement programme. The facility instituted a plan to collect antigens on a daily basis from the cold chain office.

“In the morning I will request for the type of vaccines to be used on that day from the office of the CCO. After close of business also I arrange and send the remaining vaccines that were not used on that day to the same office.” - PHC 5

Vaccine stock out

Generally, it was found that the LGA team supported facilities to ensure availability of vaccines, but this level of support was not uniform. The issue generated a lot of interest among participants as they emphatically stated that the success of the quality improvement programme depended on adequate stock level of all antigens.

“We get support from LGA, they supply us with vaccines in the event we have shortages because we immunized everybody.” – PHC 3

“we also have enough working materials and enough vaccines.” – PHC 5

In one of the facilities, BCG stock out was experience:

“last week BCG was not available, and we complained that BCG was not available, so we had to refer clients to another facility where BCG is available” – PHC 9

Concerns were expressed that if such referral was to a facility that didn't offer daily immunization like them, there are chances that they child would still be missed.

Leadership engagement within facility

We found a strong readiness for implementation in one of the facilities. This was informed by the level of within-facility leadership interest and engagement that was expressed. It seemed that there was a pre-existing internal bonding between health workers and the head of the facility, and this social capital positively influenced the QI programme implementation as well.

“our facility in charge is a hardworking officer it is because of her hard work, that we under her supervision also cooperate with her in order to achieve this success.” – PHC 5

OUTER SETTING

Lack of incentives

Despite being integrated into their routine work at the facility, participants expressed that some health workers were expecting some form of incentives. Some felt it was additional work especially those in out-patient departments.

“Initially these staffs were thinking they will be paid” – PHC 9

This posed some challenges at the initial stage as the programme was resisted in some facilities.

Acceptability of vaccines among caregivers

Vaccine acceptance also generated a lot of discussion among participants. It was found that the influence of husbands were an important impediment. Although children were making contact with health workers at service delivery points like family planning, or accompanying caregiver, attempts to offer immunization were often met with strong resistance.

“When we try to immunize her child, she will complain that her husband doesn’t know” – PHC 3

“Maybe she just came for family planning or she came to visit someone that delivered, and she came along with her child, if I try to convince her to accept immunization, she will say that the father didn’t know.” – PHC 10

Sometimes, attempts to offer immunization services among children who were visiting health facilities for other reasons evoked strong emotional responses which often discouraged the health workers from further persuasion.

“She has to tell her husband and some cry. If you want to immunize her children, she will start crying that she doesn’t want to, and you cannot force her.” – PHC 9

INDIVIDUAL CHARACTERISTICS

Self-efficacy in personnel

There is a common understanding among participants about the need for more commitment. One of the routine immunization focal persons expressed how she modified her behavior to be able to properly execute the QI intervention in an effort to achieve the desired goals for her facility.

“I come to work early because patients don’t like to wait. I bring out my data tools early and talk to patients in a nice way even if they come late. I advise them to come early. As a leader in my unit who has been trained, I have to be kind to patient because we are looking for as many children as possible to immunize.” – PHC 5

Health workers belief about the QI programme

Among the participants, the value placed on the QI programme was quite positive. Some of the health workers attested that the immunization programme in their facility improved because of the QI programme. Some of the areas of improvement that they highlighted were reduction in number of immunization defaulters and daily immunization service provision.

“Our facility has improved a lot from this QI initiative” – PHC 3

“After the first, second and third week everything changed completely. I even asked myself that is it possible for things to change within such minimal period of time.” – PHC 3

“It has benefited this facility because now our defaulters have gone down. Secondly, clients are also enjoying this thing as immunization is now on daily basis” – PHC 10

IMPLEMENTATION PROCESS

Engagement

Although only quality improvement team members from each facility attended the central training, they ensured that training was cascaded down to other health personnel in their primary health care facilities.

“After we came back from training, we also organized a stepdown training for all the staff” – PHC 5

Conducting a step-down training within facilities promoted better cooperation from other staff that were not traditionally involved with immunization:

“we got full cooperation of our staff and clients and every staff consider himself RI Focal Person because of the stepdown training we conducted and the weekly meeting that they attended.” PHC 5

Some facilities took advantage of this step-down training to include all staff including community-based personnel:

“from security guard, cleaners, casual and all staff be it professionals or non-professionals are engaged in this QI initiatives in our health facility. We also involved our TBAs that are living within the community, we train them about this program and also attend all our meetings. This TBAs used to enlighten and make women aware on the importance of immunization at any social gatherings.” – PHC 1

Weekly facility meetings

One key factor that promoted smooth and consistent execution of the quality improvement programme was the weekly facility meetings that were supported as part of the implementation strategies. This meeting served as an avenue to discuss challenges and performance.

“Another thing is we used to meet at every Thursday of the week to discuss different modalities among ourselves. This really helped us to achieve” – PHC 3

“We had to meet every week with all the heads of the units and health personnel. We sit every Thursday of the week and discuss the challenges and the achievements.” – PHC 9

In addition, the meetings were used as an avenue to conduct refresher trainings so that all health workers know more about vaccines.

“The first one we trained all our staff to have knowledge of vaccines, so every member of our staff have that things in his mind and immediately he sees the patient, first thing he will ask after greetings, what are the immunization status of your children,” – PHC 3

“every Thursday of the week all staff are invited to this meeting starting from security, casual and permanent staff of this facility. We then asked ourselves what we understand by missing opportunity child and every member must answer this question that a missing opportunity child is a person that comes to the hospital and do everything he could and walkout from the hospital without being immunized. At this meeting all of us will present what he did in the previous week under review.” – PHC 1

Integration of immunization services

One key area of where integration of immunization services was strengthened during this QI programme, based on the discussion with participants, was in maternity and labor room. However, it was still noted that health workers were reluctant to open a BCG vial for few children.

“So immediately after ANC closed from morning shift they will transfer the vaccines directly to maternity to avoid missing opportunity.” – PHC 9

“We keep two vaccines and immediately a woman give birth here we give the OPV and Hepatitis B vaccine to the child. But if it happens the woman delivers on Thursday, or in the night we usually allow her to go home with the permission of the matron in charge so that she can come back the following morning for BCG vaccine” – PHC 5

“We to take the BCG and Hepatitis B vaccine to the maternity because we used to close by 4.00pm here in the OPD. So if they have any delivery after that time, they give that immunization” – PHC 10

In fact, participants expressed that children that were delivered at home were linked to immunization services during post-natal visits:

“In the event a woman delivers at home or somewhere and come for postnatal visit and come along with the child we enquire about the child’s immunization status.” – PHC 5

Screening home-based records

Across all facilities, reminder tags were implemented across multiple service delivery points. These tags were attached to all hospital cards to prompt health workers to screen the immunization history of all children.

“We have tag which is asking about child’s status” – PHC 3

“If a patient relative comes to the maternity along with a child we also ask the mother about the child’s immunization status. If we found out that the child is not immunized, we quickly immunized him/her.” – PHC 5

It was confirmed that the use of a reminder card was necessary because health workers in service delivery points other than immunization weren't paying attention to a child immunization status or making active effort to ensure that a child is vaccinated.

Before our staff don't care whether your child is immunized or not. The concern is only to prescribe. Now, they must ask, and they have a reminder" – PHC 9

Daily immunization

Across all facilities, immunization are now provided on a daily basis. In addition to reducing missed opportunities for vaccination, participants said daily immunization has reduced workload in the immunization clinic. *"Our workload has decreases"*. With daily immunization, caregivers don't have to wait till specific days to bring their children to the hospital.

"Before we only conduct immunization on Thursday and Friday but now, we do immunization from Monday to Friday. On Saturdays and Sundays, even though we close early, maternity keeps some vaccines in case someone delivers so that the new child does not leave the facility without receiving their immunization." – PHC 3

"We now conduct immunization daily from Monday to Friday and our assignment is beyond hospital we also immunization outreach inside the community to detect defaulters." – PHC 5

"Before we are providing immunization only on Thursday, but due to implementation of this QI, we now offer immunization everyday" – PHC 10

Community defaulter tracking

We found that facilities also extended activities to community by employing social mobilization strategies to screen children within their catchment area and provide vaccination through volunteer community mobilizers (VCM).

"We also implement same in our community through our VCM to search for defaulters." – PHC 5

Use of bed nets as incentives for caregivers

We found that one of the facilities was leveraging on other public health programmes to improve completed immunization. They gave long lasting insecticide treatment nets to children who completed all the immunization in the schedule.

“We got support of mosquito nets which we distributed to any child that completed his immunization” – PHC 1.

7.4.3 Quantitative findings

The ordinal alpha for the items in each of the five domains; intervention complexity, outer setting, inner setting, individual characteristics and implementation process, were 0.67, 0.49, 0.69, 0.57 and 0.77 respectively. **Table 7.2** shows the raw scores for each of the items per facility.

Table 7.2: Raw scores for each item in the CFIR domain for each facility that implemented quality improvement in Nassarawa LGA, Kano

CFIR Domain and items	PHC 3	PHC 9	PHC 5	PHC 10	PHC 1
	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)
Intervention characteristics					
The quality improvement strategies (interventions) were locally developed by stakeholders from this health facility.	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)
Health workers from this facility were fully involved in choosing the change ideas to be tested.	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)
I trusted that this quality improvement initiative would reduce missed opportunities for vaccination and improve the performance of our immunization service.	4 (4 - 4.5)	4 (4 - 4)	5 (4 - 5)	4 (4 - 4)	4 (4 - 5)
This quality improvement approach is better than other types of interventions for reducing missed opportunities for vaccination and improving performance of immunization systems.	4 (4 - 4)	4 (4 - 5)	4 (4 - 5)	4 (4 - 4)	4 (4 - 5)
I consider quality improvement approach to be very flexible.	5 (4 - 5)	4 (4 - 4)	4 (4 - 5)	4 (4 - 4)	5 (4 - 5)
I consider this quality improvement initiatives to be very simple to implement.	4 (4 - 5)	5 (4 - 5)	4 (4 - 5)	5 (4 - 5)	5 (4 - 5)
I am very happy with the way the change ideas were delivered in cycles.	4 (4 - 5)	4 (4 - 5)	4 (4 - 5)	4 (4 - 4)	4.5 (4 - 5)
I consider quality improvement approach to be an inexpensive strategy for reducing missed opportunities for vaccination in primary health care setting.	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)
Outer setting					
I consider missed opportunities for vaccination to be a very important problem in our health facility.	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)
This primary healthcare facility is a key immunization service delivery center in this community.	4 (4 - 4)	4 (4 - 4)	4 (4 - 5)	4 (4 - 4)	4 (4 - 5)
I was interested in using quality improvement approach because I heard it has been successful in other places.	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 5)

CFIR Domain and items	PHC 3	PHC 9	PHC 5	PHC 10	PHC 1
	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)
Our facility will be rewarded by the local government and state ministry of health if we reduce missed opportunities for vaccination and improve the performance of our immunization clinic.	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)
Inner setting					
There are enough healthcare workers in this facility.	4 (4 - 5)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)
There is a health worker dedicated to managing the immunization clinic.	4 (4 - 5)	4 (4 - 4)	4 (4 - 5)	4 (4 - 5)	4 (4 - 5)
Immunization services are provided daily in this facility.	5 (4 - 5)	4 (4 - 5)	5 (4 - 5)	5 (4 - 5)	5 (5 - 5)
There was a social media group to keep everyone informed about meetings and key activities regarding quality improvement.	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)
It was easy to relate with all the members of the quality improvement team.	4 (4 - 4.5)	4 (4 - 4)	4 (4 - 5)	4 (4 - 4)	4 (4 - 4)
I will receive a financial reward for using quality improvement to reduce missed opportunities for vaccination and improving immunization services in this clinic.	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)
I will get a promotion for quality improvement to reduce missed opportunities for vaccination and improve immunization services in this clinic.	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)
It is easy to implement new ideas like quality improvement in this primary healthcare facility.	4 (4 - 4)	4 (4 - 4)	4 (4 - 5)	4 (4 - 4)	4 (4 - 5)
Mothers and caregivers consider this quality improvement initiatives to be very valuable and important.	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)
There was a good support system in place to seek more information about the quality improvement initiatives.	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)
The quality improvement team are very committed.	5 (4 - 5)	5 (5 - 5)	5 (5 - 5)	5 (5 - 5)	5 (4 - 5)
Their was easy access to information about the quality improvement initiatives that were implemented.	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 5)

CFIR Domain and items	PHC 3	PHC 9	PHC 5	PHC 10	PHC 1
	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)
Characteristics of individuals					
I was confident in myself during the implementation of the quality improvement initiatives in my facility.	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)
I was familiar with the quality improvement strategies before implementation began.	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)
I consider myself an important stakeholder for reducing missed opportunities for vaccination in this health facility.	4 (4 - 4)	4 (4 - 5)	4 (4 - 5)	4 (4 - 4)	4 (4 - 4)
I was highly motivated and competent to implement quality improvement initiatives this health facility.	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)
Process					
There was adequate planning and preparation before implementation of the quality improvement ideas commenced in this health facility.	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)
There was adequate involvement of mothers and caregivers as well as health workers in this facility in planning and implementation of the quality improvement initiatives.	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 5)
There was involvement and participation from local government health officials.	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 5)
There was a quality improvement team charged with the monitoring the change ideas.	4 (4 - 4)	4 (4 - 5)	4 (4 - 5)	4 (4 - 5)	4 (4 - 5)
There was an external person who provided support and direction for this quality improvement initiative.	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 5)
There was a good feedback mechanism for displaying progress and sharing experiences.	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)

*PHC = Primary Health Care *IQR = Interquartile Range *CFIR = Consolidated Framework for Implementation Research

PHC 1 had score of 4 (IQR:4 – 5) for intervention characteristics while other facilities had a score of 4 (IQR:4 – 4) for same domain. Similarly, PHC 1 had a score of 4 (IQR:4 – 4.5) for out setting and implementation process while other facilities had a score of 4 (IQR:4 – 4) for the domains. Other scores per facility per domain are shown on the **Table 7.3**.

Table 7.3: Raw implementation scores for each CFIR domain in facilities that implemented quality improvement in Nassarawa LGA, Kano

CFIR Domain	PHC 3	PHC 9	PHC 5	PHC 10	PHC 1
	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)
Intervention characteristics	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 5)
Outer setting	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4.5)
Inner setting	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)
Characteristics of individuals	4 (4 - 4)	4 (4 - 4)	4 (4 - 4.5)	4 (4 - 4)	4 (4 - 4)
Process	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4)	4 (4 - 4.5)

*PHC = Primary Health Care *IQR = Interquartile Range *CFIR = Consolidated Framework for Implementation Research

7.4.4 Integrated findings

As shown on **Table 7.4**, In PHC 1, the factor score for intervention characteristics was 5.40 with a standard deviation of 0.41. The illustrative quote from one of the participants in that facility suggests that the intervention is comparatively better than other interventions because it reminds health workers of their responsibilities. PHC 1 and PHC 5 had factor scores of 4.03 and 3.83 respectively for implementation process domain. The illustrative quotes indicates broad engagement of facility staff including those that are based in the community. Score and illustrative quotes for other facilities can be found on the table.

Table 7.4: A cross-case joint display showing illustrative quotes and implementation factor scores based on varimax rotation for each CFIR domain in primary health care facilities that implemented quality improvement in Nassarawa LGA, Kano

CFIR Domains	PHC 3	PHC 9	PHC 5	PHC 10	PHC 1
	Mean (SD) & Quotes	Mean (SD) & Quotes	Mean (SD) & Quotes	Mean (SD) & Quotes	Mean (SD) & Quotes
Intervention characteristics	5.23 (0.36)		5.09 (0.36)		5.40 (0.41)
	<i>"To be specific the activities is very flexible because we met and deliberated on methods or initiatives that we will apply"</i>	5.07 (0.29)	<i>"There is nothing difficult it is just to talk and convince the clients about the importance of this initiative."</i>	5.09 (0.28)	<i>"The reason why this initiative is better than others is because it reminds health workers of their responsibilities. They complain about defaulters and now there is an initiative to help reduce it. This is a very good programme."</i>
		<i>"it is flexible"</i>		<i>"It is not complex, it is flexible"</i>	
					4.38 (0.33)
Outer setting				4.17 (0.24)	<i>Sincerely, some women do not like to immunize their children. For these types of women, we take them aside and counsel them on the dangers of not vaccinating a child. They'd say it's the husband that don't want it. We then collect the husband's number and explain to them. And they usually agree."</i>
	4.18 (0.25)		4.26 (0.28)		
	<i>"When we try to immunize her child, she will complain that her husband doesn't know"</i>	4.17 (0.23)	<i>"...she said she was not interested, her husband does not like immunization at all. But by the grace of God I was able to convince her after a very long time with a patient"</i>	<i>"Maybe she just came for family planning or she came to visit someone that delivered, and she came along with her child, if I try to convince her to accept immunization, she will say that the father didn't know."</i>	
		<i>"initially these staffs were thinking they will be paid"</i>			

CFIR Domains	PHC 3	PHC 9	PHC 5	PHC 10	PHC 1
	Mean (SD) & Quotes	Mean (SD) & Quotes	Mean (SD) & Quotes	Mean (SD) & Quotes	Mean (SD) & Quotes
					4.45 (0.33)
	4.30 (0.22)				"we receive supervision from the (LIO) Nassarawa LGA he attends our meeting every week and also, they provide us with refreshment during the meeting."
Inner setting	"We receive supervision from local government, they use to come and supervised us to check how we conduct our duties."	4.36 (0.19) "the HOD had to come here for supervision to see how effective the intervention is."	4.42 (0.28) "We receive supervision from the senior officials, and they used to come from time to time."	4.37 (0.21) "There are supportive supervisions from the LGA to see how we are doing it."	
			2.97 (0.42) "I come to work early because patients don't like to wait. I bring out my data tools and talk to patients in a nice way even if they come late. I advise them to come early too. As a leader in my unit who has been trained, I have to be kind to patient because we are looking for as many children as possible to immunize."		
		2.89 (0.37)		2.79 (0.33) "It has benefited this facility because now our defaulters have gone down. Secondly, clients are also enjoying this thing as immunization is now on daily basis"	2.79 (0.23) "I got to understand that this work involves every health personnel whether you in pharmacy, lab, family planning unit or RI unit."
Characteristics of individuals	2.80 (0.31) "Our facility has improved a lot from this QI initiative"	"I go round the whole facility to maternity to ANC, from ANC to OPD to see how far, are people complying"			

CFIR Domains	PHC 3	PHC 9	PHC 5	PHC 10	PHC 1
	Mean (SD) & Quotes	Mean (SD) & Quotes	Mean (SD) & Quotes	Mean (SD) & Quotes	Mean (SD) & Quotes
					4.03 (0.43)
	3.64 (0.12)				<i>“from security guard, cleaners, casual and all staff be it professionals or non-professionals are engaged in this QI initiatives in our health facility. We also involved our TBAs that are living within the community, we train them about this program and also attend all our meetings. This TBAs used to enlighten and make women aware on the importance of immunization at any social gatherings.”</i>
	<i>Before we only conduct immunization on Thursday and Friday but now, we do immunization from Monday to Friday. On Saturdays and Sundays, even though we close early, maternity keeps some vaccines in case someone delivers so that the new child does not leave the facility without receiving their immunization.”</i>	3.75 (0.11) <i>“We had to meet every week with all the heads of the units and health personnel. We sit every Thursday of the week and discuss the challenges and the achievements.”</i>	3.82 (0.26) <i>“We also implement same in our community through our VCM to search for defaulters.”</i>	3.75 (0.11) <i>“Before we are providing immunization only on Thursday, but due to implementation of this QI, we now offer immunization everyday”</i>	
Process					

7.5 Discussion

In this study we used convergent mixed methods approach to investigate the implementation context of a collaborative QI programme in five PHC facilities in Nassarawa LGA, Kano, Nigeria, to identify implementation facilitators and barriers. Using CFIR enabled a more comprehensive formative assessment that led to the identification of actionable findings that can be used to adjust subsequent PDSA cycles.

7.5.1 Formative assessment in a QI programme to reduce MOV

The value of integrating formative assessment in health systems intervention has been emphasized by researchers (24). This study demonstrated how such assessments can be conducted in healthcare QI programmes using qualitative and quantitative data. In addition, it also led to the identification of site-specific factors that influence implementation. This can inform rapid adaption of implementation strategies and the refinement of change ideas. Hence, the study advanced the argument for embedding formative assessment in health systems programme implementation (24, 25).

Using formative assessment to evaluate contextual influencers is critical in informing a better understanding of the intervention across setting (24). In this study, it was found that health workers in PHC1 gave bed nets to caregivers that completed immunization. Similarly, health workers in PHC5 intensified their community defaulter tracking during the QI programme. These tactics are important modifications that occurred within specific sites and they might have contributed to the overall progress towards the reduction of MOV among children.

Embedding formative assessment in this QI programme provided deeper insights into the barriers that might have affected implementation within sites and impeded progress toward reduction in MOV. For example, vaccine stockout were reported in some of facilities. This is not surprising as stock out events are a common occurrence in low- and middle-income settings (26). Failure to ensure constant supply of all antigens in the PHC facilities during the QI programme would sustain the occurrence of MOV regardless of the kind of change ideas being implemented. Similarly, faulty cold chain refrigerators and negative social-cultural beliefs about immunization were reported in some sites. Thus, the persistence of MOV likely reflects the presence of these

barriers in the implementation context and not necessarily the non-effectiveness of the change ideas.

Some positive factors such as self-efficacy, confidence in the QI intervention, reported intervention flexibility, and service integration were identified as facilitators of implementation. Some of these factors were more apparent in some implementation context than others and could potentially have influenced the variation in progress towards the reduction of MOV across facilities.

7.5.1 Implications for the QI programme

Although most of the health workers described the QI programme as flexible and easy to implement and expressed that it had better relative advantage compared to other interventions, the score for intervention characteristics was not uniform across all sites. Based on the Likert scale responses, PHC 1 had the highest score in the intervention characteristics domain compared to other facilities. The high score suggests that QI team members probably engaged the rest of the staff more robustly in the pre-implementation phase to inform such positive perception. The health workers in this facility saw the intervention as an advantage to improve their work as it could reduce the number of immunization defaulters. For example, if a child who has defaulted immunization attends the out-patient department (OPD) for other childhood illnesses, they would be identified and immunized. The intervention characteristics domain gauges the perception of implementers and adopters regarding an intervention. Before commencing the next PDSA cycle, QI teams in the other PHC facilities should rigorously re-engage all health workers in their facilities in deciding the change ideas to implement.

Inner setting explored factors within the PHC system itself. One important facilitator within this domain that was consistent across all PHC facilities was supportive supervision by senior officials from the local government or primary health care management board zonal office. Supervision provides an opportunity for onsite feedback during the implementation process. In PHC 5, the implementation climate, shaped by leadership engagement was considered a facilitator. The level of respect for the facility in-charge, garnered strong commitment from the rest of the staff. Barriers that were identified within this domain include vaccine stockout and inability to sustain cold chain due to faulty infrastructure. Although the facility head in PHC 5

instituted an *ad hoc* measure to support daily collection of antigens from another site, such measures might not be sustainable in other sites without the availability of funds. Therefore, in the next PDSA cycle, a site-specific mechanism should be put in place to facilitate the collection of antigens from the local government expanded programme on immunization (EPI) office. For sustainability, the local government EPI manager needs to strengthen the system to prevent vaccine stockout, especially for Bacillus Calmette-Guerin (BCG). Overall, PHC 1 and PHC 5 still had higher scores in this domain compared to other facilities.

The outer setting broadly encompasses all external influences (12). In this study we found barriers that are related to policies (lack of incentives) and the socio-cultural beliefs of caregivers. The QI programme didn't include incentives as part of the change ideas. Caregivers resist immunization if their husband didn't give prior approval. Although health workers usually counsel caregivers on the benefits of vaccines and initiate phone conversation to persuade their husbands, to comprehensively address this problem, community-wide behavior change interventions are necessary.

Health worker behavior can influence the implementation of interventions (12). In this study, we identified self-efficacy and beliefs about the QI as important facilitators. When an individual believes in their capabilities to implement an intervention, they modify their behavior to achieve the desired goal. This was apparent among health workers in some of the PHC facilities. In PHC 5, one of the health workers said that she modified her work resumption time in order to provide immunization services to more children. Furthermore, health worker beliefs and perception about an intervention is important (12). The value placed on an intervention, which is largely informed by background working knowledge of that intervention influences adoption (12).

Implementation process explored the activities that were implemented during the PDSA cycles. One key facilitator within this construct that was consistent across the PHC facilities was the integration of immunization services in the maternity section of the facilities which included antenatal and family planning clinic, or labor room. Service integration is considered an important investment area for immunization programmes and is a key component of GVAP (27). Other activities in the QI programme were implemented across all facilities.

7.5.2 Limitations and strengths

Although all health workers in the five PHC facilities were included, we were limited by sample size. As such, our findings are not generalizable. However, as a formative evaluation, the intention is to provide facility-specific feedback that can be used to enhance the QI programme. Since the rating tool collected self-reported data, social desirability bias is a potential limitation. The convergent mixed methods design enabled the integration of quantitative and qualitative data which improved the validity of our findings. This mixed methods design allowed us to gain additional insights into the implementation context of the QI programme across facilities.

7.6 Conclusion

This study demonstrated that theory-driven formative evaluation can be integrated in a QI programme in a low resource setting. It buttresses the value of conducting such assessments as they can be used to generate rapid feedback on context specific factors which can then be addressed in subsequent PDSA cycles. CFIR proved to be a useful theoretical framework as it facilitated the systematic analysis of multidimensional factors.

7.7 Competing interest

None declared

7.8 Author contribution

The study was conceptualized by AAA. He conducted the interviews, analyses, interpreted findings, produced the first draft, and revised subsequent drafts. CSW, OAU, MAG reviewed and approved the study concept, supervised and contributed to analysis and interpretation, and manuscript development. All authors approved the final manuscript.

7.9 References

1. World Health Organization. Planning guide to reduce missed opportunities for vaccination. Geneva, Switzerland: World Health Organization; 2017.
2. World Health Organization. Standards for improving the quality of care for children and young adolescents in health facilities. Geneva, Switzerland.2018.
3. National Primary Healthcare Development Agency and National Bureau of Statistics. Nigeria National Immunization Coverage Survey 2016/17, Final Report. Abuja, Nigeria: National Primary Healthcare Development Agency and National Bureau of Statistics; 2017.
4. Adamu AA, Uthman OA, Wambiya EO, Gadanya MA, Wiysonge CS. Application of quality improvement approaches in health-care settings to reduce missed opportunities for childhood vaccination: a scoping review. *Human vaccines & immunotherapeutics*. 2019;1-10.
5. Dixon-Woods M, McNicol S, Martin G. Ten challenges in improving quality in healthcare: lessons from the Health Foundation's programme evaluations and relevant literature. *BMJ Qual Saf*. 2012;21(10):876-84.
6. Powell AE, Rushmer R, Davies H. A systematic narrative review of quality improvement models in health care: NHS Quality Improvement Scotland; 2009.
7. Ferlie EB, Shortell SM. Improving the quality of health care in the United Kingdom and the United States: a framework for change. *Milbank Q*. 2001;79(2):281-315.
8. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. *Implementation science : IS*. 2009;4(1):50.
9. Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O. Diffusion of innovations in service organizations: systematic review and recommendations. *Milbank Q*. 2004;82(4):581-629.
10. Rycroft-Malone J, Gill H, Kitson A. Getting evidence into practice: ingredients for change. *Nursing Standard (through 2013)*. 2002;16(37):38.
11. Mendel P, Meredith LS, Schoenbaum M, Sherbourne CD, Wells KB. Interventions in organizational and community context: a framework for building evidence on dissemination and implementation in health services research. *Adm Policy Ment Health*. 2008;35(1-2):21-37.
12. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. *Implementation science*. 2009;4(1):50.
13. Nilsen P. Making sense of implementation theories, models and frameworks. *Implementation science : IS*. 2015;10(1):53.
14. Creswell JW, Clark VLP. Designing and conducting mixed methods research: Sage publications; 2017.
15. Morgan DL. Practical strategies for combining qualitative and quantitative methods: applications to health research. *Qual Health Res*. 1998;8(3):362-76.
16. Duncan EAS, Nicol MM. Subtle Realism and Occupational Therapy: An Alternative Approach to Knowledge Generation and Evaluation. *British Journal of Occupational Therapy*. 2016;67(10):453-6.
17. Kibon UA, Ahmed M. Distribution of Primary Health Care Facilities in Kano Metropolis Using GIS (Geographic Information System). *Research Journal of Environmental and Earth Sciences*. 2013;5(4):167-76.

18. Makama SD. 2006 National Population and Housing Census. Abuja: National Population Commission, Commission NP; 2010.
19. National Population Commission. Population and housing census of the Federal Republic of Nigeria. Priority tables. 2006;1.
20. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of biomedical informatics*. 2009;42(2):377-81.
21. Brooks J, McCluskey S, Turley E, King N. The utility of template analysis in qualitative psychology research. *Qualitative Research in Psychology*. 2015;12(2):202-22.
22. Gadermann AM, Guhn M, Zumbo BD. Estimating ordinal reliability for Likert-type and ordinal item response data: a conceptual, empirical, and practical guide. *Practical Assessment, Research & Evaluation*. 2012;17(3).
23. Zumbo BD, Gadermann AM, Zeisser C. Ordinal versions of coefficients alpha and theta for Likert rating scales. *Journal of modern applied statistical methods*. 2007;6(1):4.
24. Stetler CB, Legro MW, Wallace CM, Bowman C, Guihan M, Hagedorn H, et al. The role of formative evaluation in implementation research and the QUERI experience. *J Gen Intern Med*. 2006;21 Suppl 2(Suppl 2):S1-8.
25. Dolin J, Black P, Harlen W, Tiberghien A. Exploring relations between formative and summative assessment. *Transforming assessment*: Springer; 2018. p. 53-80.
26. Lydon P, Schreiber B, Gasca A, Dumolard L, Urfer D, Senouci K. Vaccine stockouts around the world: Are essential vaccines always available when needed? *Vaccine*. 2017;35(17):2121-6.
27. World Health Organization. Global vaccine action plan 2011-2020. Geneva, Switzerland: World Health Organization; 2013.

Chapter 8: Overall Conclusion

Childhood immunization is considered an essential evidence-based intervention for ensuring child survival, as it can prevent death and disability from vaccine-preventable diseases (VPD) (1). However, only 10% of children aged 12 – 23 months in Kano State, Nigeria are fully immunized according to the 2017 National Immunization Coverage Survey (2). In order to increase childhood immunization coverage, the missed opportunities for vaccination (MOV) strategy was developed by the World Health Organization to target children aged 0 – 23 months (3). The MOV strategy leverages on existing health facilities that offer immunization services (3). Implementing the MOV strategy in a low immunization coverage setting like Kano can increase the immunization rate in healthcare facilities thereby increasing the population of children that are protected from VPDs in the community.

Research on MOV in low-and middle-income (LMIC) countries have largely focused on MOV assessments, which provides information on prevalence and contributing factors within specific settings (4, 5). But MOV assessment is only one of the components of the MOV strategy (3). In this PhD project, we advanced MOV research by generating evidence on how quality improvement (QI) can be used in primary health care facilities (PHC) to reduce MOV. In addition to existing evidence on factors that are responsible for MOV, context-specific factors were also explored. These were used to tailor the change ideas to local context to ensure “innovation fit”. Furthermore, the implementation context was assessed to identify barriers and facilitators of implementation success. The feedback was then used to improve subsequent PDSA cycles. Finally, experiences from this study was used to inform a framework that can guide further implementation of QI in similar settings to reduce MOV.

To answer the overarching research question in this PhD project, several sub-questions were addressed. They are as follows:

What is the overall prevalence and dynamics of missed opportunities for vaccination among children aged 0 – 23 months attending healthcare facilities in Africa?

A systematic review and meta-analysis was conducted to identify published and unpublished MOV assessments that were conducted in Africa (6). A total of 20 studies met the inclusion criteria and these studies were conducted in 14 African countries (6). Out of them, three were conducted in Nigeria, but none were in Kano (6). Proportions from individual studies were

extracted, normalized, and then used to fit a random effects model (6). The model estimated the pooled prevalence of MOV among African children aged 0 – 23 months in healthcare facilities to be 27.26% (6). Using systems dynamic modeling, the extracted factors from individual studies were used to build a causal loop diagram (6). This diagram revealed seven reinforcing loops and two balancing loops (6). The findings from this study suggested that MOV is a common problem in health facilities in Africa (6). It was also shown to be a complex problem as factors were found to be interrelated (6). However, this study highlighted important evidence gaps as MOV assessment in low coverage settings like Kano were not found.

What is the nature and extent of use of quality improvement approaches in health facilities to reduce missed opportunities for vaccination within the context of routine childhood immunization?

Based on the finding from the systemic review, the factors that are responsible for MOV in health facilities are complex. Therefore, health systems approach that accounts for complexity is necessary to address it. In recent times, is a growing interest in the use of QI as an approach for addressing complex problems in complex health systems as it enables implementation of multifaceted interventions in an iterative and systematic manner (7). However, the extent to which QI has been used to address MOV is unknown. For this reason, a scoping review was conducted to identify published and unpublished literature on quality improvement interventions that have been implemented in health facility settings to reduce MOV (8). A total of 12 articles were identified (8). Multifaceted interventions targeting healthcare providers, service users, and health systems were identified (8). The result also suggested an increase in the use of QI to address MOV, however, all the QI interventions were conducted in the United States (8).

What are the predictors of missed opportunities for vaccination among children aged 0 – 23 months attending primary health care facilities in Nassarawa Local Government Area of Kano State, Nigeria?

Although QI has been used in other settings to address MOV as shown in the scoping review, no evidence were found in low-and middle-income countries including Nigeria. Therefore, a pilot QI programme was implemented to demonstrate its feasibility. In the pre-implementation phase of this QI programme which was implemented in Nassarawa Local Government Area (LGA) of Kano State, Nigeria, contextual factors that are associated with

MOV were determined using quantitative data. This data were collected from 10 randomly selected PHC facilities. Caregivers of 675 children aged 0 – 23 months were interviewed. Immunization histories were obtained from their home-based records or temporary immunization documents. The prevalence of MOV among the children was 36.16%, and MOV was highest for inactivated polio vaccine. Using multilevel analysis technique, we demonstrated that contextual factors influences the magnitude of MOV between facilities. The fixed effect model showed that MOV was more likely to occur among children who were accompanying a caregiver to the health facility, children who were not vaccinated on the day of visit, and those who visited clinics with three or more vaccinators.

Based on the experiences of caregivers, what factors are responsible for missed opportunities for vaccination among children less than two years who attend primary health care facilities in Nassarawa Local Government Area of Kano State, Nigeria?

In addition to quantitative data, qualitative data were also collected. This was to gain a deeper insight into the factors that are responsible for MOV from the perspective of caregivers. Focus group discussions were held with caregivers in three purposively selected PHC facilities. Five discussions were conducted with 30 caregivers. These focus group discussions enable deeper exploration of caregivers' perspective from their lived experiences regarding childhood immunization and MOV. The analysis approach was through the lens of the theoretical domains framework. Some of the factors that featured most prominently included non-screening of home-based records (HBR), refusal to offer immunization services, spousal refusal for socio-cultural reasons, fear of side-effects, and inadequate knowledge about the vaccines that a child needs. The contextual factors that were identified in this setting confirms some of the linkages that were shown the causal loop diagram that was constructed for the first research question. For example, husbands refusal is related to traditional beliefs and customs, failure to offer immunization on the day of visit and refusal to offer vaccination have to do with vaccination scheduling. In addition, non-screening of home-based records is already illustrated in reinforcing loop R7. A new factor; accompanying a caregiver to the health facility, was identified and this can extend the causal diagram.

Can quality improvement reduce missed opportunities for vaccination among children aged 0 – 23 months attending primary health care facilities in Nassarawa Local Government Area of Kano State, Nigeria?

To address the contextual factors that were identified, a QI programme was initiated in five purposively selected PHC facilities with the aim of reducing the proportion of MOV. Health workers in these facilities used divergent-convergent thinking to identify context-specific change ideas that targets these factors. Change ideas that were considered “fit” for the setting were selected. They were simple and required low effort to implement considering the workload in the facilities. The change ideas included use of reminder tags, daily immunization in facilities, dissemination of educational materials on MOV, immunization at multiple service delivery points, and persuading fathers who refuse vaccination through phone calls. Packages of change ideas were implemented over two plan-do-study-act (PDSA) cycles that were four weeks apart. Progress towards improvement was monitored using p-charts. Six weeks after implementation began, progress towards the improvement aim (reduction in MOV among children aged 0 – 23 months) became apparent in two facilities.

What contextual factors affect the implementation of a quality improvement programme to reduce missed opportunities for vaccination among children aged 0 – 23 months attending primary health care facilities in Nassarawa Local Government Area of Kano State, Nigeria?

The level of progress towards reduction in the proportion of MOV was not uniform across all PHC facilities that implemented the change ideas in this quality improvement programme. This could be as a result of the varying context across the facilities. To explore this, a mixed methods study with qualitative and quantitative data from PHC facilities that implemented the QI programme was conducted to gain a deeper understanding of the implementation context. The findings suggested that factors such as vaccine stockout, faulty cold chain infrastructure, lack of incentives, and socio-cultural beliefs were common in facilities that didn't show progress towards improvement. While factors such as self-efficacy among health workers and integration with community activities to track defaulters were found in facilities that showed progress toward improvement. Health systems factors such as vaccine stockouts and faulty cold chain infrastructure emerged for the first time, but this is not surprising because data were obtained from health workers. Based on these, actionable recommendations that could be applied in the subsequent cycle were made.

This PhD project contributed to existing knowledge in several ways:

- a. Employing systematic evidence synthesis methodologies to generate evidence about the burden of MOV and the extent to which quality improvement has been used to address MOV in healthcare setting.

- i. A systematic review and meta-analysis of observational studies was conducted to estimate the prevalence of MOV in Africa, and systems thinking was innovatively integrated within the framework of this systematic review to describe the factors that are responsible for MOV, elucidating complexity and leverage points for intervention.
- ii. A scoping review of the extent to which QI approach has been used to addressed MOV in the healthcare facility setting was conducted.
- b. Using theory-driven process of inquiry to explicate factors that are responsible for MOV from the perspective of caregivers and factors that influence the implementation success of the QI programme in primary health care facilities.
 - i. The factors that are responsible for MOV were analyzed through the lens of the theoretical domains framework (TDF).
 - ii. The consolidated framework for implementation research (CFIR) was used guide a formative assessment to study the implementation context of the QI programme.
- c. Using advanced statistical techniques like multilevel modeling in an MOV assessment that involves multiple facilities to determine the predictors of MOV among children aged 0 – 23 months.
- d. Leveraging on lessons from empowerment evaluation and integrating some of its values in the model for improvement framework to preemptively address factors that can affect implementation and adoption of selected change ideas for reducing MOV.

8.1 Recommendations

1. There is a need for more MOV assessment among children aged 0 – 23 months that are conducted in line with WHO's methodological guidance across different levels of healthcare in Africa, and particularly in Nigeria. This will enable the generation of a more reliable pooled effect measure.
2. Our findings suggest that many children who are eligible for vaccination do not make contact with health facilities. Based on the National Immunization Coverage Survey, only 10% of children in Kano are fully immunized. However, we found the prevalence of MOV for one or more vaccines to be 36.15%. Therefore, community-based interventions that target eligible children who do not make contact with the PHC facilities are necessary.

3. The evaluation of the QI programme was conducted within six weeks of implementation, which is considerably early. To maintain consistent use of the QI interventions, there is a need for booster sessions with the health workers.
4. The QI programme that was piloted in this study only included five facilities. Scaling this programme to other facilities in the LGA could have an impact on cross-site implementation fidelity. Therefore, there is a need to build in mechanisms to continuously assess and sustain fidelity.

8.2 Limitations of this PhD project

As part of this PhD project, two reviews were conducted. The causal loop diagram that was constructed as part of the systematic review was validated by the authors and this aided a qualitative description of the interrelatedness of the factors that are responsible for MOV. Although quantitative techniques like factor analysis could be used to explore how the factors correlate with each other, the intention was to explicitly describe them to identify leverage points for intervention. In the scoping review, only 12 QI projects were found. Given the growing interest in applying QI in healthcare setting, it is possible that other unpublished reports were missed.

In this PhD project, the MOV assessment that was conducted only explored caregiver perspectives. Even though this enabled the identification of several factors that were addressed in the quality improvement programme, including health workers' perspectives would have aided a more comprehensive MOV assessment. Nevertheless, limiting the assessment to caregivers was sufficient to answer the research questions that were set out in the project.

The outcomes were evaluated early, after six weeks of commencing the plan-do-study-act cycles. However, this early evaluation provided useful insight into facilities where improvement had begun to occur and sites that were not making progress.

Our findings may not be generalizable to the entire state as this project was limited to only one out of the 44 local government areas in Kano State. This was due to funding limitations. If given an opportunity to repeat this study with more funding, it would be scaled-up to more local government areas; both urban and rural, across the three senatorial districts in Kano State, Nigeria.

8.3 Strengths of this PhD project

The foundation of this project was laid by a systematic review and meta-analysis of observational studies, which curated existing MOV assessments that were conducted in healthcare facility settings in Africa (6). The review was thorough as it was conducted in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline (6). The comprehensive search involved five electronic databases, with no date, language or data format restriction (6). Eligibility criteria were specified a priori (6). Three authors screened titles and abstracts, and two authors independently performed the data extraction (6). This review led to the generation of a pooled prevalence of MOV among children aged 0 – 23 months in Africa (6). In addition, systems thinking was innovatively used in this review to describe the factors that are responsible for MOV. This elucidated the complexity of the problem (6).

Using Arksey and O'Malley's framework, a scoping review was used to generate evidence on the extent to which quality improvement has been used to address MOV (8). Three databases were searched without restrictions (8). Then, two authors independently selected eligible studies and extracted information (8). The review identified several multifaceted change ideas which were implemented in health facility settings to improve routine immunization rates and reduce missed opportunities for vaccination (8). It was informative to know the kind of stakeholders that had been targeted in previous quality improvement interventions.

The evidence generated from the research syntheses that were conducted as part of this PhD project contributed to the existing knowledge base. The systematic review highlighted important evidence gaps in the setting where this PhD project was conducted, as no previous MOV assessment was found from Kano, despite being a low immunization coverage setting. Also, there is a lack of quality improvement research from sub-Saharan Africa, and in particular, Kano, which has a significantly high number of unvaccinated and partially vaccinated children.

The selection of change ideas in this PhD project was informed by primary qualitative and quantitative studies that were conducted in the pre-implementation phase of the quality improvement project. In the qualitative study, the perspective of caregivers of children aged 0 – 23 months attending primary health care facilities in Nassarawa, Kano, regarding immunization and MOV was sought. The thematic analysis was guided by an existing

theoretical framework which led to the identification of important behavioral factors. In the quantitative study, multilevel analysis technique was used since clustered data were collected from children aged 0 – 23 months attending primary health care facilities in Nassarawa, Kano. This allowed for the formation of random intercept variance. Both studies led to the identification of context specific factors that are responsible for MOV among children aged 0 – 23 months attending primary health care facilities in Nassarawa local government area of Kano State, Nigeria. This contributed to the current knowledge base by demonstrating how theory-driven qualitative enquiry approach can be used to gain deeper insight on the phenomenon of interest in a QI programme. In addition, this demonstrated the practicality of conducting multilevel modeling in a collaborative QI programme (that involves multiple primary health care facilities).

Local stakeholders and decision makers were robustly engaged. Before commencing the programme, stakeholders were informed, and the concept was discussed extensively. In the pre-implementation phase, health workers and decision makers were trained on quality improvement and MOV, and change ideas were selected by them. This improved their buy-in and commitment. In addition, an existing framework was used to guide the implementation strategies.

Rooted in subtle realism paradigm, mixed methods design was used to conduct a formative assessment that evaluated the implementation context of the quality improvement programme (9). Qualitative data was used to complement quantitative data. This enabled the identification of contextual factors that limited progress toward the desired goal and allowed formulation of actionable recommendations. This contributed to existing knowledge by demonstrating how theory-driven formative assessment can be integrated in a QI programme.

Drawing on the findings from the sub-studies in this PhD project, a framework was proposed to guide the use of QI as an MOV strategy.

8.4 A proposed quality improvement framework for missed opportunities for vaccination strategy

The quality improvement framework for MOV strategy is a refinement of the theoretical framework of this PhD project. The planning, implementation and evaluation phases of the theoretical framework are broken down into specific steps that are oriented around the PDSA cycle. This is to ease the application of QI in an MOV strategy.

A 12-step approach as shown in **Figure 8.1** is recommended. The planning phase begins with stakeholder's engagement. This is to ensure buy-in and commitment throughout the process. At this stage, local immunization stakeholders are sensitized to the MOV strategy and how it can improve immunization coverage at the district and even national level. Evidence from similar settings can be presented to improve confidence in the strategy. A "go-ahead" to commence MOV assessment by stakeholders is necessary. The next step is to conduct field work to quantify the magnitude of MOV. This serves at least two purposes. First, it's a source of baseline data for the QI programme. Secondly, it can generate context-specific factors. In step three, the data is analyzed. Then, group brainstorming with local stakeholders and frontline health workers is used to identify potential solutions which can serve as change ideas. Choice of change ideas should be "fit" for the context. Also, low-cost ideas should be prioritized. In step five, consensus should be reached among all stakeholders – decision makers and practitioners, regarding the change ideas that are fit for their context. The implementation (Do) phase involves systematic implementation of the change ideas across selected facilities. At this stage it is important to build the capacity of all stakeholders on MOV and QI. It is essential to document all procedures conducted at this phase. In the study (evaluation) phase, progress towards improvement is evaluated. The evaluation technique should depend on the design used. It is essential that local stakeholders have the skills to monitor progress towards improvement. In addition, formative assessments should be conducted to understand the influence of context on the implementation process. If the desired reduction in MOV is attained based on evidence from the study phase, then the act phase is initiated. At this level the change package is fully implemented.

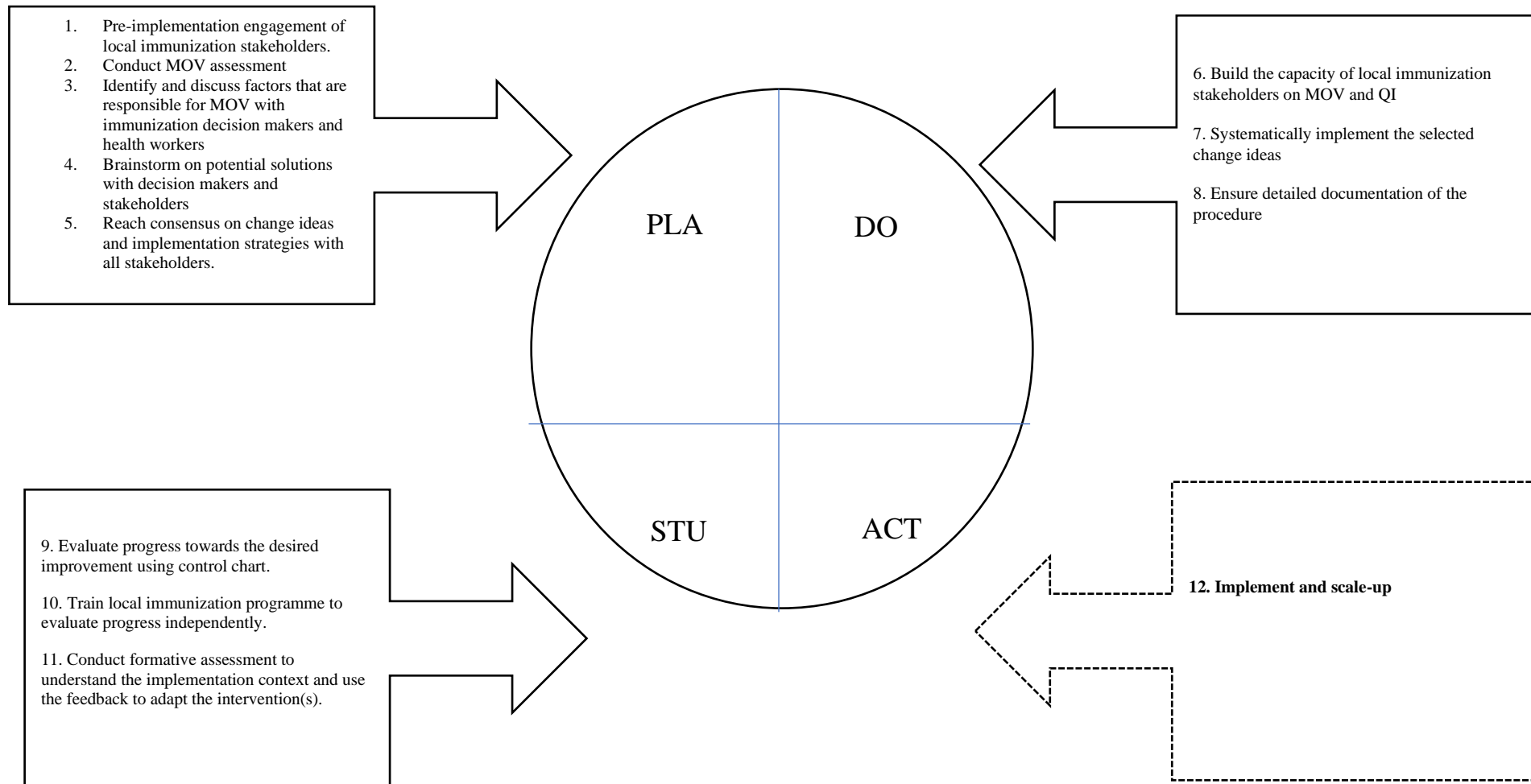


Figure 8.1: Quality improvement framework for missed opportunities for vaccination strategy

8.4 References

1. Delany I, Rappuoli R, De Gregorio E. Vaccines for the 21st century. *EMBO Mol Med*. 2014;6(6):708-20.
2. National Primary Healthcare Development Agency and National Bureau of Statistics. Nigeria National Immunization Coverage Survey 2016/17, Final Report. Abuja, Nigeria: National Primary Healthcare Development Agency and National Bureau of Statistics; 2017.
3. World Health Organization. Planning guide to reduce missed opportunities for vaccination. Geneva, Switzerland: World Health Organization; 2017.
4. Hutchins SS, Jansen HA, Robertson SE, Evans P, Kim-Farley RJ. Studies of missed opportunities for immunization in developing and industrialized countries. *Bull WHO*. 1993;71(5):549-60.
5. Sridhar S, Maleq N, Guillermet E, Colombini A, Gessner BD. A systematic literature review of missed opportunities for immunization in low- and middle-income countries. *Vaccine*. 2014;32(51):6870-9.
6. Adamu AA, Sarki AM, Uthman OA, Wiyeh AB, Gadanya MA, Wiysonge CS. Prevalence and dynamics of missed opportunities for vaccination among children in Africa: applying systems thinking in a systematic review and meta-analysis of observational studies. *Expert Rev Vaccines*. 2019;18(5):547-58.
7. Shojania KG, Grimshaw JM. Evidence-based quality improvement: the state of the science. *Health Aff (Millwood)*. 2005;24(1):138-50.
8. Adamu AA, Uthman OA, Wambiya EO, Gadanya MA, Wiysonge CS. Application of quality improvement approaches in health-care settings to reduce missed opportunities for childhood vaccination: a scoping review. *Human vaccines & immunotherapeutics*. 2019:1-10.
9. Hammersley M. Ethnography and realism. *The qualitative researcher's companion*. 2002:65-80.

Appendices

Appendix 1: MOV assessment tool - exit interview questionnaire

Respondent ID _____

HEALTH FACILITY CHARACTERISTICS

1. Name of health facility _____
2. Coordinates _____
3. Name of ward _____
4. Type of health facility
 1. Comprehensive health center
 2. Health post
 3. Health clinic
 4. Dispensary
5. Total number of health workers _____
6. Number of vaccinators _____
7. Is there a health worker primarily stationed in vaccination clinic?
 - 1] Yes
 - 2] No
8. Characteristics of location
 - 1] Slum area
 - 2] Non-slum area
9. How many hours of electricity supply do you get in this facility?
10. What is the source of water supply in this health facility?
 - 1] Pipe borne
 - 2] Well
 - 3] Borehole
 - 4] None
 - 5] Others

SECTION A: CHILD DATA

1. Date of birth _____
2. Age (in months) _____
3. Sex
 - 1] Male
 - 2] Female
4. Birth order
 - 1] First
 - 2] Second
 - 3] Third
 - 4] Others (specify)
5. Why did you bring the child to this health facility today? (Do not read options)
 - 1] For medical consultation (child is sick)
 - 2] For vaccination
 - 3] Growth and Development Check-up
 - 4] Child is only accompanying (not for treatment/vaccination)
 - 5] Hospitalization (Child was admitted or still on admission)
 - 6] Others (Please specify)

SECTION B: MOTHER/CAREGIVER DATA

- [illegible]

22. Do you feel you know the vaccines your child needs? 1] Yes 2] No 3] Not sure
23. If yes, do you feel that you know when the vaccines should be given? 1] Yes 2] No 3] Not sure
24. Has this child ever been vaccinated? 1] Yes 2] No
25. If no, why not? 1] The necessary vaccines or supplies were not available 2] I am not in favor of vaccination 3] My husband/the decision maker is not in favor of vaccination 4] I have not visited the health facility on a vaccination day 5] I did not know that the child was eligible to be vaccinated 6] Others (Please specify)
26. Have you ever requested vaccination services for this child and been refused? 1] Yes 2] No
27. If yes, why didn't they vaccinate the child? 1] The health worker said it couldn't be done because the child was sick 2] There were no vaccines or there were no syringes or some other supply needed for vaccination 3] it was not a vaccination day 4] The vaccination area was closed 5] The person in charge of vaccination was not there 6] There would have been a long wait 7] We didn't have the vaccination card with us 8] The hours for vaccination are limited 9] Others (Please specify)
28. In your home who makes the decision to vaccinate? 1] Father 2] Mother 3] Other relatives 4] Consensus of father and mother 5] Others (Specify) _____

SECTION C: USE OF VACCINATION CARD AND INFORMATION ON VACCINES ADMINISTERED

29. Does your child have a vaccination card? 1] Yes, and I have it with me 2] Yes, but I do not have it with me 2] No
30. If no, does your child have documented vaccination records? 1]] Yes 2] No
31. Do you have your child's vaccination card or any vaccination records with you today? 1] Yes 2] No
32. Could you tell us why you do not have the vaccination card or temporary vaccination documents with you today? 1] It is at the school/day care center 2] I left it at home

because I forgot to bring it 3] I left it at home because I didn't know it was important to bring along 4] I lost it 5] The care has been damaged 6] I have never been given one 7] Because vaccination was not the reason for this visit 8] Others (Please specify)

33. If no to question 29, why don't you have a vaccination card? 1] I lost it 2] I have never been given one 3] I don't know 4] Others (Please specify)

34. What vaccines has the child received till date? (Obtain information only from vaccination card, vaccination register, or other temporary vaccination documents)

Name of Vaccine (Antigen)/Dose	Date of administration

35. Have you ever lost the vaccination card? 1] Yes 2] No

36. If yes, did you encounter difficulty getting it replaced? 1] Yes 2] No

37. Could you tell me what purpose the vaccination card serves? 1] Don't know 2] To know what vaccines the child has had and which are missing 3] Overall health record and growth monitoring 4] Record and remind for return visit dates 5] Birth certificate and/or identification 6] Others (Specify)

38. Have you ever been charged for vaccines given to a child? 1] Yes 2] No

39. If yes, in what type of health facility was it? 1] Public 2] Private 3] Don't know

40. Have you ever been asked to pay for a vaccination card? 1] Yes 2] No

41. If yes, in what type of health facility was it? 1] Public 2] Private 3] Don't know

SECTION D: TODAY'S VISIT

42. During today's visit, did the health worker ask you for the child's vaccination card? 1] Yes 2] No
43. If no, did they ask for the vaccination status of the child? 1] Yes 2] No
44. Was your child vaccinated here today? 1] Yes 2] No
45. Why was your child not vaccinated today? 1] The health worker said that the child was not eligible for vaccination today. 2] The health workers who saw us did not tell me about vaccinating the child 3] The health worker said that the child could not be vaccinated because s/he was sick 4] The last time the child was vaccinated s/he got sick or had a reaction 5] My religion does not permit vaccination or I don't believe in vaccines 6] Vaccination was not the purpose of this visit 7] The child is already fully vaccinated for his/her age 8] I don't trust the health workers or vaccines in this health facility 9] I forgot to take my child to the vaccination area 10] I didn't have time today to wait for vaccination 11] There were no vaccines in the health facility today 12] There were no syringes or other vaccination supplies 13] Today is not a vaccination day in this health facility 14] The vaccination area was closed 15] The person in charge of vaccination was not there 16] There would have been a long wait 17] The staff treated us badly 18] Other (please specify)
46. If because of illness, what type of disease does the child have or treatment received today? 1] Minor illnesses such as mild fever, cold, cough, or diarrhea 2] Major illnesses requiring admission such as severe pneumonia or severe malaria 3] Other illnesses such as intestinal worms, malnutrition, anemia, dehydration or urinary tract infection 4] Child is taking medications (please specify name) 5] HIV/AIDS 6] Others (Please specify)
47. If your child was eligible for vaccination but was not vaccinated today, did the health worker refer you to or inform you about where you can receive the missing vaccine doses? 1] Yes 2] No

SECTION E: QUALITY OF VACCINATION SERVICES

Instruction: Complete this section only if the child received vaccination today

48. How long did you wait for your child to be vaccinated? _____ Hours
 _____ Minutes
49. Did they tell you today what vaccines they gave the child? 1] Yes 2] No
50. Today, did they tell you the date for the child's next vaccination appointment? 1] Yes
 2] No
51. Today, did they write down for you the next vaccination appointment? 1] Yes
 2] No
52. Did you receive information today on the reactions or side effects that can occur
 following vaccinations? 1] Yes 2] No
53. If yes, what did they tell you? 1] Pain at injection sites 2] Fever 3] Rash
 4] Diarrhea 5] Vomiting 6] Others (Please specify)
54. Did you receive information today on what you should do if the child has reactions or
 side effect to the vaccines? 1] Yes 2] No
55. Are you satisfied with the services provided today? 1] Yes 2] No
56. If yes, why? 1] Immediate attention 2] Friendly treatment by staff 3] No charge for
 services 4] The necessary vaccines and supplies were available 5]
 Others (Specify)
57. If no, why? 1] Had to wait a long time 2] The staff was discourteous 3] The
 language that the health worker use is not clear 4] They did not explain what
 vaccines they had given the child 5] The necessary vaccines and supplies were not
 available 6] Others (Specify)

SECTION F: REASONS TO VACCINATE CHILDREN

58. Could you tell me the purpose of vaccines? (Multiple responses allowed) 1] To prevent
 diseases 2] So children will grow up healthy 3] To cure diseases 4]
 They don't do any good 5] Not sure what they are for 6] Other (Please specify)
59. What diseases do vaccines prevent? (Multiple responses allowed) 1] Tuberculosis 2]
 Hepatitis 3] Polio 4] Diphtheria 5] Pertussis 6] Tetanus 7]
 Pneumonia 8] Meningitis 9] Diarrhea 10] Influenza 11] Measles 12] Rubella
 13] Mumps 14] Yellow fever 15] Cancer (please specify) 16] Others
 (Specify) 17] Don't know

60. Do you think your child could get these diseases if you don't vaccinate him/her? 1] Yes
2] No 3] Don't know

61. What suggestions do you have to improve vaccination services? 1] There should be more vaccination personnel 2] There should be less waiting time 3] Hours and days when vaccinations are available should not be limited 4] Vaccination cards should remain free 5] The treatment of the public and of the children being vaccinated should be friendlier 6] The health center should always have vaccines 7] The should provide information on the vaccines that are being given, on the diseases that they prevent, and on the reactions that they produce. 8] More outreach services 9] None 10] Don't know 11] Others (Please specify)

Appendix 2: MOV assessment focus group discussion guide

Before we begin, does anyone have any questions?

Opening Questions

Let's start with some introductions. Can we go around the circle and everyone say their name and the ages of their children? You can feel free to introduce yourself with any name you choose.

1. What are some health problems that affect children in this community?
2. How are your children protected from being affected by these health problems/diseases?
 - a. **Probe: If vaccination is not mentioned, ask: *What about vaccination?***

Key Questions

General Vaccination

3. Tell me what you feel about vaccines. Probe: Do you think they are important? Why?
Why not?
4. How does the community feel about childhood vaccination?
5. How well do women and caregivers in this community know about vaccination and vaccination schedule. Do you think they know the vaccines that are being administered to their children? Who is usually responsible for ensuring a child is vaccinated? And why?
Are people aware of the consequences of not vaccinating a child? Why?
6. What can you tell us about childhood vaccination services in this community?
 - a. Probe for their levels of satisfaction with the vaccination services they receive from primary healthcare center (e.g. **What is good and what is not so good about the vaccination services?**)
 - b. Probe for **reasons** for their satisfaction or dissatisfaction (e.g. Why?)
7. In your opinion, what are some of the ways these vaccination services can be improved?

Vaccine Compliance

8. How would you describe compliance with vaccination schedules in this community?

a. Probe: Reasons why some of the children do not receive their vaccines at the appropriate time

9. What will be your suggestion for helping children to receive all their recommended vaccines according to the schedule?

Missed Opportunities

10. In some cases, children who visit health facilities, for different reasons, still do not get all the needed vaccines. In your opinion, what are some reasons **some health workers** may not be willing or able to give children all their recommended vaccines on time, when they visit the clinic/hospital?
11. Some children receive some, but not all the vaccines they need. In your opinion, what are some of the reasons **mothers/caregivers** may not be willing or able to ensure that their children receive all their recommended vaccines on time when they visit the clinic/hospital?
12. What are the **ways you can recommend** for ensuring that children receive all their recommended vaccines on time whenever they have the opportunity of visiting a clinic/hospital for any reasons? (They may be visiting for immunization, nutrition, treatment of other ailments, or accompanying an adult to the clinic/hospital)?

Closing questions

13. Are there any additional suggestions/ideas you would like to share at this time? Anything else to add?

Appendix 3: Interview guide to assess health workers experience with implementing quality improvement initiatives

INTRODUCTION

1. Please describe your role in this health facility
2. What was your role in this quality improvement initiative
3. What specific function did you play during implementation of this quality improvement initiative

DESCRIPTION OF IMPLEMENTATION

Describe how the QI initiative was implemented in your health facility. Please specify dates of the key activities that were implemented (if you can remember).

What kind of interventions were implemented in this facility. How were they implemented?

What kind of materials were used for the intervention? Where they enough?

Who implemented the interventions? Tell me what you know about them.

PRE-IMPLEMENTATION EXPERIENCES

Tell me how the QI intervention started. How did your facility become involved? How were you engaged to participate in the QI intervention?

What did you see that showed whether this QI initiative would work? Did you know about QI before this initiative started? How was this initiative better than other interventions you've participated in?

To what extent did other health workers buy-in to this QI initiative? Do you think this kind of initiative is important? Tell me more about how it has benefited this facility. To what extent has it served its purpose? Tell me more about how you think it served a purpose?

IMPLEMENTATION EXPERIENCES

Describe your experiences during the implementation of this QI initiative. What kind of support did you get? Tell me about the problems you experienced? What were the facilitators you experienced?

Describe your planning process for implementation of this QI initiative? How did you keep track of the tasks that needed to be done?

What kind of support did you get during the implementation of this QI initiative?

Were the activities flexible? How?

OVERALL EXPERIENCE

Did you enjoy participating in this QI initiative? Tell me why.

Level of endorsement

How successful do you think this QI initiative was? What do you mean by success? *Define your success. Rate the success of this initiative on a scale of 0 – 10. Would you want to continue implementing this QI initiative? What would it take to continue this initiative in this facility? Would you recommend a similar QI initiative to other facilities? What are your suggestions for improving this QI initiative?

Appendix 4: Quality improvement rating tool

SECTION A: BACKGROUND INFORMATION

Age _____

Sex 1] Male 2] Female

Level of Education 1] No formal education 2] Primary education only 3]

Secondary education 3] Post-secondary education

Cadre of health worker 1] Community health worker 2] Environmental Health

Assistant 3] Auxiliary nurse 4] Registered Nurse 5] Pharmacy technician

6] Pharmacist 7] Medical doctor 8] Others

SECTION B: EVALUATION OF COMMUNITY QI

INTERVENTION CHARACTERISTICS

The quality improvement strategies (interventions) were locally developed by stakeholders from this health facility

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

Health workers from this facility were fully involved in the choosing the change ideas to be tested

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

I trusted that this quality improvement initiative would reduce missed opportunities for vaccination and improve the performance of our immunization service

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

This quality improvement approach is better than other types of interventions for reducing missed opportunities for vaccination and improving performance of immunization systems

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

I consider quality improvement approach to be very flexible

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

I consider this quality improvement initiatives to be very simple to implement

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

I am very happy with the way the change ideas were delivered in cycles

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

I consider quality improvement approach to be an inexpensive strategy for reducing missed opportunities for vaccination in primary health care setting

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

OUTER SETTING

I consider missed opportunities for vaccination to be a very important problem in our health facility

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

This primary healthcare facility is a key immunization service delivery center in this community

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

I was interested in using quality improvement approach because I heard it has been successful in other places

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

Our facility will be rewarded by the local government and state ministry of health if we reduce missed opportunities for vaccination and improve the performance of our immunization clinic

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

INNER SETTING

There are enough healthcare workers in this facility

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

There is a health worker dedicated to managing the immunization clinic

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

Immunization services are provided daily in this facility

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

There was a social media group to keep everyone informed about meetings and key activities regarding quality improvement

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

It was easy to relate with all the members of the quality improvement team

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

I will receive a financial reward for using quality improvement to reduce missed opportunities for vaccination and improving immunization services in this clinic

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

I will get a promotion for quality improvement to reduce missed opportunities for vaccination and improve immunization services in this clinic

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

It is easy to implement new ideas like quality improvement in this primary healthcare facility

Mothers and caregivers consider this quality improvement initiatives to be very valuable and important

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

There was a good support system in place to seek more information about the quality improvement initiatives

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

The quality improvement team were very committed

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

There was easy access to information about the quality improvement initiatives that were implemented

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

CHARACTERISTICS OF INDIVIDUALS

I was confident in myself during the implementation of the quality improvement initiatives in my community

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

I was very familiar with the quality improvement strategies before implementation began

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

I consider myself an important stakeholder for reducing missed opportunities for vaccination in this health facility

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

I was highly motivated and competent to implement quality improvement initiatives in this health facility

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

PROCESS

There was adequate planning and preparation before implementation of the quality improvement ideas commenced in this health facility

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

There was adequate involvement of mothers and caregivers as well as health workers in this facility in planning and implementation of the quality improvement initiatives

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

There was involvement and participation from local government health officials

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

There was a quality improvement team charged with the monitoring the change ideas

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

There was an external person who provided support and direction for this quality improvement initiative

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

There was a good feedback mechanism for displaying progress and sharing experiences

1] Strongly disagree 2] Disagree 3] Neutral 4] Agree 5] Strongly agree

Appendix 5: Stellenbosch University ethics approval letter



Health Research Ethics Committee (HREC)

Approval Notice

New Application

18/04/2018

Project ID :6357

HREC Reference # S18/02/044 (PhD)

Title: Using quality improvement approach to address missed opportunities for vaccination in Kano Metropolis, Nigeria

Dear Dr Abdu Adamu

The **New Application** received on 02/03/2018 18:06 was reviewed by members of **Health Research Ethics Committee** at a meeting on 04/04/2018 and was approved.

Please note the following information about your approved research protocol:

Protocol Approval Period: **This project has approval for 12 months from the date of this letter.**

Please remember to use your project ID (6357) on any documents or correspondence with the HREC concerning your research protocol.

Please note that the HREC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

After Ethical Review

Translation of the informed consent document(s) to the language(s) applicable to your study participants should now be submitted to the HREC.

Please note you can submit your progress report through the online ethics application process, available at: Links Application Form Direct Link and the application should be submitted to the HREC before the year has expired. Please see [Forms and Instructions](#) on our HREC website (www.sun.ac.za/healthresearchethics) for guidance on how to submit a progress report.

The HREC will then consider the continuation of the project for a further year (if necessary). Annually a number of projects may be selected randomly for an external audit.

Provincial and City of Cape Town Approval

Please note that for research at a primary or secondary healthcare facility, permission must still be obtained from the relevant authorities (Western Cape Department of Health and/or City Health) to conduct the research as stated in the protocol. Please consult the Western Cape Government website for access to the online Health Research Approval Process, see: <https://www.westerncape.gov.za/general-publication/health-research-approval-process>. Research that will be conducted at any tertiary academic institution requires approval from the relevant hospital manager. Ethics approval is required BEFORE approval can be obtained from these health authorities.

We wish you the best as you conduct your research.

For standard HREC forms and instructions, please visit: [Forms and Instructions](#) on our HREC website <https://applyethics.sun.ac.za/ProjectView/Index/6357>


If you have any questions or need further assistance, please contact the HREC office at 021 938 9677.

Yours sincerely,

Mr. Franklin Weber

HREC Coordinator

Appendix 6: Kano State Ministry of Health ethics approval letter

 KANO STATE OF NIGERIA MINISTRY OF HEALTH 2nd & 3rd Floor, Post Office Road, P.M.B. 3066, Kano.	<p><i>Commissioner: 08023337417</i> <i>Permanent Secretary: 09096619985</i> <i>website: www.kanostateministryofhealth.gov.ng</i></p>
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Ref: <u>MOH/Off/797/T.I/374</u>	Date: <u>5th Feb 2018</u>
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Dr. Abdu A. Adamu
(Student Number 20506546)
Department of Global Health,
Faculty of Medicine and Health Sciences,
Stellenbosch University
Tygerberg Campus
Cape Town,
South Africa.

RE: APPLICATION FOR ETHICAL CLEARANCE

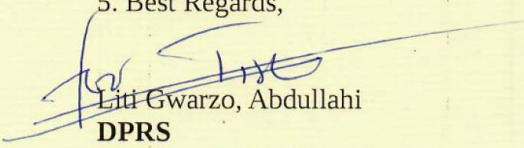
Reference to your letter dated 5th May 2017 on the above request addressed to the Chairman Ethics Sub-Committee of Health Operational Research Unit of the Ministry requesting for ethical approval to conduct a doctoral (PhD) research at health facilities in Fagge, Nassarawa and Dala local government areas in Kano.

2. The research entitled *“Using Quality Improvement Approach to Address Missed Opportunities for Vaccination in Kano Metropolis, Nigeria”* is for the award of Doctor of Philosophy Degree in Epidemiology (PhD Epidemiology).

3. In view of the foregoing, I wish to convey the Ministry’s approval for you to conduct the research at the above mentioned local governments in Kano.

4. You are also requested to share your findings with the Ministry of Health, Kano.

5. Best Regards,


Liti Gwarzo, Abdullahi
DPRS
Secretary (ORAC)
For: Honourable Commissioner

Appendix 6: Aminu Kano Teaching Hospital ethics approval letter



AMINU KANO TEACHING HOSPITAL

P. M. B. 3452, ZARIA ROAD, KANO.

(☎:07068297399)www.akth.info/www.akth.gov.ng, E-mail: enquiries@akth.info/akthkano@yahoo.com

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MBBS, FMCS, FICS

DIRECTOR OF ADMINISTRATION

ADAMU HUSSAINI ALIYU

NHREC/21/08/2008/AKTH/EC/2296

AKTH/MAC/SUB/12A/P-3/VI/2396

1st August, 2018

Dr. Abdu A. Adamu
Department of Community Medicine
AKTH, Kano.

Ufs:

The Head of Department
Community Medicine
AKTH, Kano.

ETHICS APPROVAL

Further to your application in respect of your research proposal titled "Using Quality Improvement Approach to Address Missed Opportunities for Vaccination in Kano Metropolis, Nigeria", The Committee reviewed the proposal and noted same as a prospective involving focal group discussion.

In view of the above, Ethics approval is hereby granted to conduct the research.

However, the approval is subject to periodic reporting of the progress of the study and its completion to the Research Ethics Committee.

Regards,

Abubakar S. Mahmud
Secretary, Research Ethics Committee
For: Chairman

